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Estimates of the Benefits and Costs From Reductions in Grass Seed Field Burning

June 1997*

*Revised publication version. The version contains format edits and copy edits to the "Estimates" report dated January 7, 1997. Both versions are available for review. No substantive changes were made from the January 7, 1997 version.

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Executive Summary

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Washington Department of Ecology
Air Quality Program
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Report Summary

On March 29, 1996, the Department of Ecology issued an emergency ruling that called for a one-third reduction in the number of acres of field and turf grasses that could be burned in Washington in 1996. A permanent rule requiring an additional one-third reduction in 1997 is currently being considered. Specifically, the proposed rule would modify WAC 173-430, to require "burning of field and turf grasses for seed in 1997 and thereafter (until approved alternatives become available) be limited to no more than the larger of one-third of the number of acres permitted to burn in 1995 or in grass seed production on May 1, 1996. This report presents information on the probable economic benefits and costs that would result from a limitation on grass seed field burning and a consequent reduction in grass smoke.

Benefits and Costs

We estimate that probable benefits of the proposed reduction in grass seed field burning will exceed probable costs. Our best estimate of probable benefits is **$8.4 million** per year and our best estimate of probable costs is **$5.6 million** per year. Both costs and benefits include uncertainty so we estimated ranges for the probable values. We estimate total probable benefits between $6.6 and $10.2 million and total probable costs between $3.9 million and $7.9 million. There is considerable overlap in these ranges, but in our estimation the <u>probable</u> benefits are greater than the <u>probable</u> costs. Our estimates compare the pre-rule situation with the reduction of burning on two-thirds of bluegrass acreage.

Probable economic costs of the proposed rule stem from the limitation on grass seed field burning. Limitations on grass seed field burning reduces returns for grass seed farmers. Farm losses may come from reduced bluegrass yields, increased costs, or the reduced returns from an alternative crop. Besides these direct farm income losses, costs include environmental costs due to increases in soil loss from wind and water erosion, losses in the seed processing sector, and losses in jobs and income in the wider community. Other costs include emotional costs to those who lose jobs or suffer business losses, potential changes in farm accident rates due to changes in farm practices, and the costs of administering the program. The largest share of the cost is incurred by the grass-seed production sector.

The largest potential benefit of the proposed rule is improved air quality from reduced smoke emissions. Epidemiological evidence has established a clear link between small airborne particles and health, particularly for an at-risk population comprising people with existing cardio-pulmonary conditions such as asthma, emphysema, chronic bronchitis or heart disease.[1]

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[1]There is also some speculation that the higher rate of asthma found in Spokane compared to other regions may be due to the higher levels of particulate pollution in the Spokane area. Since this possibility is still speculative it was not counted in the study. Recent work at Eastern Washington University also indicates a possible link between smoke from field burning and cancer.

Additional benefits from the proposed rule include the benefits of traffic accident reductions, enhanced recreational opportunities, reduced dirt and nuisance effects from smoke particles, and the aesthetic effects of improved visibility.

In our studies we constructed some greatly higher cost estimates and some significantly lower cost estimates. Likewise we generated some significantly lower benefit estimates and some vastly higher benefit estimates compared to those reported above. However, these higher and lower cost and benefit estimates were based on less dependable estimation procedures or on unrealistic premises and were therefore not reported as part of the probable range. Those interested are directed to the detailed and technical reports.

The basic results of our study are described in the following summary. The larger report details how the estimates of probable benefits and costs were estimated. A series of technical appendices contain the detailed studies that generated the data leading to the benefit and cost estimates.

Estimated Costs

Since there is uncertainty about the impact of the proposed rule, our estimation of probable costs began by examining a number of possible scenarios for the impact of the rule. The final estimated range for economic costs was based on two scenarios that represent the likely outcomes of the rule. A final, best estimate was based on the most realistic features of these two benchmark scenarios.[2]

Cost estimates were based on an estimate of a little over 60,000 acres of planted bluegrass. We used past burn permits, conservation plans filed with the Farm Service Agency, and processor information about seed volume to estimate this acreage. Since the rule permits continued burning on one-third of the acreage until suitable non-burn technologies are certified, our estimates are based on the two-thirds or about 40,000 acres affected by the rule.

Table one shows the breakdown of the costs for each scenario. This table shows the estimated costs for the alternative version of the rule that includes a 5 percent exemption for land that is deemed extraordinarily difficult to cultivate using alternative (non-burn) technologies and a provision allowing growers to trade burn permits within local jurisdictions. Under this rule, fields that were certified by a conservation official as being extraordinarily difficult to cultivate would be given an exemption--with exemptions limited to 5 percent of the fields. In other words, burning would be allowed on at least 33 percent and as much as 38 percent of a farmer's fields depending on field conditions.

[2]We calculated costs for about a dozen different scenarios. Many of these scenarios were calculated to test the impact of particular effects by taking them to an extreme; for example the loss of all affected grass acres. These different scenarios generated costs ranging from about $1.4 million to as much as $14 million--a tenfold difference. However, the range of estimates on the scenarios considered probable are those given above.

Adoption of the alternative version of the rule reduced costs by about $300,000 on the best cost estimate compared to the rule version that includes no exemption. (Analysis of the basic version of the rule can be found in the full report and the technical appendices.) This rule will also reduce benefits, but our benefits estimates were not finely tuned enough to estimate the value of this variation of the rule.

The benefits from trading were not explicitly estimated due to lack of appropriate data. The benefits of trading are that, once the overall desired limit on burning is set, farmers are able to increase efficiency--"fine-tuning" their farming by using burned bluegrass on the fields most productive under burning. Since we modeled farms in only two broad classes, irrigated and dryland, we were not able to capture the efficiencies that result from shifting burning from one field to another with different productivity and farming cost characteristics. We therefore expect costs lower than those reported here under the alternative version of the rule. In principle, the trading provision will not decrease benefits because it does not change the overall level of burning. However, in practice it is possible that some fields will be burnt that would otherwise not be burned. For instance, if a farmer had most of his bluegrass fields in a rotation (establishment, "take-out" year) where he did not need to burn, he might sell his permit and thereby increase the total burn.

It is also important to note that the impact of the trading provision will depend, among other things, on the scope of area for the rule. If permits were tradable across all of eastern Washington, it is likely that irrigated farmers would sell permits to dryland farmers, especially those in the Spokane area. Such a version of the rule would reduce the benefits of the rule, perhaps substantially. It is therefore assumed here that trading will be within local jurisdictions only.

Rotational Burn Cost Scenario

The estimate of total costs of a little under $4 million for the lower end of the probable cost range is based on an assumption that farmers will innovatively adapt to the rule change. We used a scenario of rotational burning to represent this innovation.

Burning is used in bluegrass farming primarily to remove residue--straw and thatch. If residue is not burned it must be removed some other way, generally by mechanically raking and bundling; otherwise seed yields will be drastically reduced. Even with mechanical raking and disposal of the residue, many studies show a yield penalty compared to burning. Our analysis assumes such a yield penalty. Therefore, use of non-burn technologies affects farm returns through both lower yields and higher costs compared to annual burning.

Under rotational burning of bluegrass fields, farmers would burn all bluegrass acres, but burn each field only every other year. Non-burn technologies would be employed in the alternate year. Because of the reduced yields and increased costs of mechanical residue removal, we

Table 1: The Probable Costs

Cost component	Cost estimates ($1000s) Rotation Scenario	Half-out scenario	Most probable scenario
Farm costs	$3,000	$5,120	$3,548
(No. jobs lost)	(+3)	(21)	(0)
Environmental costs	$0	$270	$270
Processing costs	$0	$477	$369
(No. jobs lost)	(0)	(9)	(0)
Economic impact costs	$552	$1,098	$586
(No. jobs lost)	(18)	(19)	(18)
Other costs	$388	$944	$790
TOTAL COSTS	$3,940	$7,909	$5,562

estimate that farmers and farm workers would lose about $3 million of income compared to pre-rule circumstances. While substantial, these losses are lower than the farm losses that would occur under most alternative scenarios we analyzed.

By using rotational burning, bluegrass acreage can be maintained at pre-rule levels. In a six year rotation farmers burn two times or one-third of the time. The reason that farmers can burn only two of six years in a rotation instead of three of six years is that fields are not burned in the establishment year. We also assumed that fields are not burned in the last ("take-out") year. Under current conditions some farmers like to burn in the last year, but this burn is for disease and weed control rather than for enhancing yields. So, in a six year rotation farmers would burn the third and fifth years and use non-burn residue removal in the second and fourth years. (A table in the full report shows the rotation more clearly.)

Some land is not suitable for non-burn technology and so would have to be burned every year or go out of bluegrass (for example, because it is too steep). However, the 5 percent exemption and the trading provision of this version of the rule should permit continued bluegrass cultivation on all acreage in this scenario.

Because bluegrass acreage is not reduced in this scenario, there are no environmental costs. Bluegrass reduces wind and water erosion compared to alternatives like wheat and is often recommended as part of conservation rotations. Also, since bluegrass seed production is reduced minimally, processors are not affected.

We also estimated impacts on the rest of the economy due to the "ripple" effects from reduced spending by farmers and workers in the bluegrass sector. We estimate these impacts at $552,000 in the rotational burning case. Generally, benefit cost studies do not count the indirect loss of jobs and the ripple effect of lost income in the rest of the economy. It is usually assumed that this secondary lost business and jobs will be made up elsewhere in the economy. However, in this case the comments at hearings and the results of the survey we conducted (primarily for our contingent valuation estimate of benefits) made it clear that people were concerned about the potential economic impact on the local economy of any losses to the bluegrass seed industry. We therefore examined these impacts more closely than is customary. We used a regional economic impact model to analyze the probable community economic impacts. Input-output estimates are biased upwards because they assume all job losses or business income losses are permanent. Our economic impact cost estimates are therefore adjusted to account for the rate at which lost jobs and business are made up by economic activity elsewhere. We used relatively high estimates of these "ripple" impact costs.

The rotational burning scenario is an example of the kind of innovation that may follow adoption of the burn rule. Other innovations might include better mechanical thatch removal and the development of seed varieties that maintain high yields under non-burn cultivation methods. Past experience indicates that it is highly likely that the agricultural industry will find an innovative way to adapt to the rule change so we place a high probability on this scenario. (See, e.g., Moore and Villarejo.) However, it will also take time for such innovations to be developed and shorter term losses are likely to be greater than those portrayed in this innovative technology scenario.

Half-Out Scenario

The estimate of about **$7.9 million** for the high end of the range of probable costs is based on the assumption that no change is made from currently available technology and current farm practices. We should be clear that this is not the highest cost we explored but the high end of what we estimate to be the range of probable costs[3]. In the half-out scenario we assume that farmers respond to the rule change using only current technology and farming practices. Current technology includes the machinery now developed for thatch removal and the current seed stocks. This estimate is also based on the current cost of non-burn technology for straw removal and a prediction of little or no increase in bluegrass seed prices even if production falls.

These assumptions are cautious. It is possible that the price of machinery for non-burn residue removal will fall somewhat when machinery is produced in larger quantities, and it is probable that some improvements in machinery will be made. It is likely that seed varieties optimized for non-burning cultivation will be developed. Also, it is very likely that grass seed prices will rise if supply is reduced. There are also emerging industries that would create a market for bluegrass straw, thereby reducing the cost of straw removal, and perhaps even generating a payment for the straw. Since any straw market is still speculative, we have made the assumption that there is no market for bluegrass straw (although we studied the potential impacts of such a market). In short, we assume none of these potentially mitigating developments in our half-out scenario which is why we consider it the top end of the probable cost range.

[3] For instance, we analyzed the impact if all of the affected bluegrass acres (two-thirds of the total) go out of production and all job and income losses are permanent in one of the scenarios of our input-output model. While it is possible that all of the irrigated farms could switch out of bluegrass, it is very unlikely that all dryland fields will be switched to other crops. It is also very unlikely that all those who lose jobs will never again be employed.

The half-out scenario also assumes that most of the lost bluegrass acreage would go into wheat while a small proportion goes out of production altogether. For dryland fields this is the most likely outcome, but for irrigated fields there are more profitable alternatives than wheat, so this estimate is probably a bit high. Overall, we estimate that the bluegrass farm sector would lose about $5.1 million in lost farm returns and lost jobs in these circumstances.

In this scenario we estimate substantial lost bluegrass acreage in Washington--about 20,000 out of an estimated 60,000 total acres. We estimate that about half the affected bluegrass acres will move to an alternative use and half will stay in bluegrass production using non-burn technology. (This means that two-thirds of the original acreage will remain in bluegrass.) Switching one-third of the land from bluegrass to wheat will create environmental costs of about $270,000. It also means that the processing industry will suffer losses due to reduced bluegrass supply--though some or all of this might be made up by bluegrass seed planted elsewhere. We assumed about half would be replaced. The processing industry will suffer income and job losses of about $477,000.

We also estimate that the rest of the economy would suffer economic losses of about $1.1 million of lost jobs and business income. These are secondary losses due to lost purchases by the bluegrass production and processing sectors. They were estimated with the input-output model and account for re-employment using the same assumptions as for the rotational burn scenario.

Other costs include the cost of some bluegrass smoke which will be shifted to residents of northern Idaho as more production is moved into Idaho. We counted $324,000 in damages from the shifted smoke. The shifted cost estimate was based on the fact that these households would not get the full amount of the benefits from the adoption in the rule. Specifically, we calculated that half the lost grass-seed production would be replaced by Idaho grown grass-seed and that half of that would be grown in the Coeur d'Alene area.

We also included $160,000 in administrative costs. We added an extra margin of 5 percent on potential job and business losses to account for the emotional costs of these losses--about $460,000 in this scenario.

Another potential cost is the change in accident rates for farmers as they change production practices. We found no data on changes in accidents rates on which to build a cost estimate. However, we did make an illustrative calculation of the possible actuarial costs of any increases in accidents. Although any specific accident may have high medical and emotional costs, we found the potential monetary value of such costs low compared to the other costs, based on the probability of an accident in any given year.

Most Probable Cost Scenario

The above two scenarios bracket what we think are probable costs. Some innovative scenario like the rotational scenario is highly probable, but its actual nature is unknown so the cost estimates are imprecise. On the other hand, the estimate based on the half-out scenario is likely to be a bit high, but the costs are based on what is known to be feasible under current technology and farming practices. The half-out scenario is probably a good representation of what will happen in the short run while the industry adjusts to new conditions. However, a more likely estimate of costs after a year or two of adjustment can be obtained. We estimated a most probable impact based on using cautious, but more realistic assumptions from the two bracketing scenarios.

We believe that the most realistic assumption is that the bluegrass industry would adapt to a large degree but that some bluegrass production would nonetheless be lost. It is also probable that there would be some increase in bluegrass seed prices but, to be cautious, we assume none. To approximate the most likely outcome, we constructed a scenario in which half of the affected acreage (20,000 acres) switches out of bluegrass, but the acreage remaining in bluegrass (40,000 acres) adopts an innovative technology like the rotational burning cultural practice.

For this scenario we estimate total probable costs of about $5.6 million. The cost breakdown (Table 1) follows the same patterns explained for the other two cost scenarios. Direct farm income and job costs are a little higher than for the rotational burn scenario at $3.5 million. This estimate includes environmental costs which are the same as for the half-out scenario at $270,000. It also includes impacts on the processing sector of about $369,000 since some seed production is lost. Impacts on the general economy are about $586,000 in lost job and business income with the same assumptions about the rate at which lost jobs and business are replaced in the economy. Costs of shifted smoke, program administration, and emotional losses for lost jobs and income total $790,000.

Economic Benefits

We estimate probable benefits of the rule at between $6.6 to $10.2 million. Our most reliable estimate is that benefits will be about **$8.4 million.** This is a reliable, but cautious estimate of benefits. For instance, using an alternative, less dependable estimation technique, we estimate potential benefits of between $9 and $18 million. While these estimates are less reliable than the primary estimate, they suggest that it is unlikely that the primary estimate is overstated.

Willingness to Pay–Survey Estimates

Our principal estimation method is based on directly estimating the value of smoke reduction from the point of view of the average household in the affected area. This method estimates combined health and non-health benefits. To estimate this value we conducted a scientific, random sample survey of households in Spokane, other affected areas of Eastern Washington, and parts of Northern Idaho. We obtained 1,561 completed surveys. We used a standard economic valuation technique called the contingent valuation method. In the contingent valuation method households are asked how much they would be willing to pay (WTP) for implementation of the rule to reduce smoke from bluegrass seed field burning. To get reliable estimates survey respondents were asked to imagine they were voting in a referendum about whether to approve and pay for the smoke reduction program--the proposed rule. The willingness to pay estimate for the sample is then extrapolated to the overall population of the area.

Our best estimate of $8.4 million in benefits is based on this technique. The range around the estimate is based on the margin of error in extrapolating the benefit value from the sample population to the total population. Our use of a relatively large sample (1,561 households) compared to many studies of this type helps to minimize this margin of error.

Epidemiological-Economic Estimates

The alternative benefits estimation method uses an indirect method based only on potential health benefits. This is a two step procedure based on combining epidemiological and economic techniques. We first estimate the potential exposure of the affected population and the resulting probable change in medical and mortality impacts due to the improvements in air quality using the results of epidemiological studies. There is a large epidemiological literature documenting the health effects of small airborne particles. Particles from combustion processes appear to have larger health impacts than ordinary dust particles. The potential impacts of reduced particles include reduced medical costs, reduced loss of wages due to lost work, reduced "pain and suffering" and, most importantly, reduced mortality.[4] Once the potential improvements are identified, monetary values are estimated. The monetary values for impacts like asthma attacks are obtained from standardized values based on previous economic studies. We estimated benefits of between $9 and $18 million using this two step procedure.

The estimates based on this epidemiological-economic approach are imprecise. We lack detailed information on how the smoke reduced by the rule would reduce the exposure of the affected population. We had to use general estimates of this exposure, since the detailed monitoring and smoke modeling necessary to determine exposures have not been done. More detailed exposure knowledge would allow us to make more precise estimates of the health effects because we have very good information on the effects of particulate exposure from the extensive epidemiological literature on the impacts of airborne particles on human health. However, we had to use available estimates of the smoke exposure, which means these health cost estimates are imprecise.[5]

It is interesting to note, however, that the estimate of health benefits from reducing smoke actually exceeds the willingness-to-pay estimate. This is a paradox because the WTP estimate is supposed to include both health and non-health benefits. There are several reasons for this apparent paradox. One has been mentioned; the epidemiological-economic estimates of health benefits are imprecise.

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[4] The health effects of exposure to other constituents of smoke (such as volatile gases) were not estimated. Moreover the possibility that long term exposure to smoke and particles may increase the rate of asthma or of lung cancer were not used because reliable epidemiological estimates are not available.

[5] Another source of variance in the estimates is the assumed cost of mortality. The cost of mortality is the major component of benefits in this approach. We used medium to low estimates for the cost of mortality.

A second reason that the WTP estimate may be lower than the health based estimate is that many respondents did not like the fact that the proposed rule to reduce smoke would impose a burden on local farmers. They, therefore, discounted the value they were willing to pay for the program to account for this negative impact. This can be seen especially outside the Spokane and North Idaho areas. While the majority of households in Spokane and Northern Idaho favor the proposed rule, the majority of residents in other areas of Eastern Washington oppose the rule. Moreover, statistical analysis showed that those who felt the proposed rule would impose a burden on agriculture were more likely to oppose the proposed rule. These results imply that the willingness to pay for the smoke production is a net value: that is, the value of the benefits of smoke reduction to households reduced by a penalty or cost for the burdens of the program.

Finally, a third reason that the WTP estimate is low is that it measures benefits only from a private perspective. This means that, in evaluating their costs, households consider their costs for, say, hospitalization, but not the cost paid by insurance, other businesses, or government programs. This means that the survey based WTP benefit estimate is likely to be understated because it does not include costs to general businesses and the public. Thus, losses to the recreation industry in Northern Idaho are not included, though the cost of lost recreation days to the individual are included. The health exposure based estimates are also understated because they do not include non-health benefits at all. Therefore, the primary estimate of benefits is a conservative estimate.

Compensation Based Estimate

Besides the willingness to pay and epidemiological-economic estimates, a third estimate of benefits could be made based on the assumption that the population affected by smoke has the right to be free of smoke. If they have the right to be free of smoke they should not have to pay to get reduced smoke, they should be compensated for any damages caused by continued burning. This approach produces much larger estimates of the value of smoke reduction, over $30 million.

We put less emphasis on these estimates than the other two benefits estimates for conceptual and practical reasons. Conceptually, the question of whether it is the right of farmers to burn their fields or the right of local residents to clean air that should be paramount is a legal and moral question beyond the scope of this study. However, the main reason we put less emphasis on this estimate is that the method used for estimation of compensation is unreliable. We used the same survey to estimate compensation as we did for willingness to pay. However the compensation value is based on a very small number of respondents making it hard to generalize to the whole population, and respondent reporting patterns are less stable for compensation questions giving rise to a great range of individual value estimates. Most economists and government agencies disallow compensation estimates for these practical reasons. For instance, the National Oceanic and Atmospheric Administration disallows compensation estimates based on the recommendations of a blue ribbon panel of economists.

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Project Report

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Submitted by:

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Introduction: Purpose and Limitations of the Study

On March 29, 1996, the Department of Ecology issued an emergency ruling that called for a one-third reduction in the number of acres of field and turf grasses that could be burned in Washington in 1996. A permanent rule requiring an additional one-third reduction in 1997 is currently being considered. Specifically the proposed rule would modify WAC 173-430 to require burning of field and turf grasses for seed in 1997 and thereafter (until approved alternatives become available) be limited to no more than the larger of one-third of the number of acres permitted to burn in 1995 or in grass seed production on May 1, 1996. This report presents information on the probable economic benefits and costs that would result from a limitation on grass seed field burning and a consequent reduction in grass smoke.

Study Method

The purpose of an economic benefit-cost analysis is to provide a systematic and comprehensive comparison of the positive and negative impacts of a proposed program (e.g., the proposed burn reduction rule). Aside from the legal requirement, the economic evaluation will help understand what is being sacrificed to attain the goals of the program. Often all of the impacts (positive and negative) are not understood without a systematic analysis. Moreover, a systematic accounting puts into perspective the individual benefits and costs, which when considered one at a time may be misleading about the desirability of the project. Finally, the economic evaluation is also likely to illuminate methods for mitigating some of the potential sacrifices.

A list of impacts includes financial costs to farmers and grass seed processors, environmental losses from increased erosion, and losses to the general economy. Benefits include improvements in the health of people with lung and heart conditions, reductions in human lives lost, improvements in the aesthetics of air quality, and increases in recreational activities because of the improved environmental conditions.

The economic evaluation method uses monetary equivalents to put all effects into one common denominator. While using monetary equivalents is sometimes offensive to some people, it does provide a comprehensive and standardized valuation system by which all effects can be compared. Nonetheless, it would be asking too much of economic analysis to claim that economic values capture <u>all</u> the value of some specific impact. Thus, an individual human life is priceless--and so is a great work of art or a pristine environment. Moral and aesthetic judgements cannot be <u>reduced</u> to economic values, but economic evaluation is useful for comparing all benefits and costs.

Unless stated otherwise, this analysis employs the general conventions of benefit-cost analysis. Benefit-cost analysis counts costs and benefits from the national perspective to whomsoever they accrue. One implication of these assumptions is that environmental costs are counted even though they are not incurred directly by farmers. Another implication is that costs to residents of Idaho and other states as well as to Washington residents should be counted if the Washington rule affects them.

The two central concepts used to create the consistent valuation scheme is that economic costs are opportunity costs (e.g., the medical cost of treating smoke induced illness is the lost opportunity to use those medical resources to treat other illnesses) and that economic values are the price that people would be willing to pay for a (increment of a) desired item or prices they would be willing to accept as compensation (sell) for an item or service that is lost. (See Carruthers, *Ecology Economics Resource Book* for further discussion.)

Input-Output Analysis

Generally, benefit-cost studies do not count the indirect loss of jobs and the ripple effect of lost income in the rest of the economy. It is usually assumed that secondary lost business and jobs will be made up elsewhere in the economy. However, in this case the comments at hearings and in the survey we conducted made it clear that people were concerned about the potential economic impact on the local economy of any losses to the bluegrass seed industry. Therefore, we examined secondary impacts more closely than is customary.

In benefit-cost analysis, these secondary costs are usually not counted because it is assumed that the value of the lost production is captured by the loss in the output of the good, valued at its selling price. Benefit-cost (B/C) analysis is based on two assumptions. The first assumption is that the economy is at full employment. This means that all labor, capital, and land is being used for some productive activity. Second, the standard benefit-cost study assumes that factors are flexible and mobile. Each factor has a back-up use--an opportunity cost. If it were not employed in its present use, it could be employed elsewhere, at almost the same level of productivity.

Based on this full employment (flexible factor assumption) most benefit-cost analyses assume that any labor or capital thrown out of work will instantly find itself re-employed. Under this assumption as one reduces sales at the local supermarket and restaurant, offsetting increases in sales are occurring at another community's supermarket and restaurant as the released laborers and capital equipment go elsewhere.

In contrast, the input-output (I/O) assumption is that any factor that is thrown out of production will stay out of production. Suppose reduced bluegrass production means reduced income to community farmers leading to lower sales at the local fast food place which leads to firing of a local high school teenager. In the input-output framework the teenager never gets another job--at least in the region of the input-output analysis. In the framework of benefit-cost analysis, the teenager is hired the instant he walks out the door of his old employment. Obviously neither assumption is very realistic. The total input-output impact overestimates the impact; the standard benefit-cost assumption underestimates the impact. The actual impact will vary depending upon the rate of re-employment. The rate of re-employment will depend on the flexibility of the resource and the vigor of the economy in generating new opportunities. Re-employment will be faster in good economic times than bad.

There are other differences between the input-output approach and benefit-cost analysis. For instance, I/O analysis looks at the overall impact on economic activity, whereas B/C analysis views economic impacts through the normative lens of benefits and costs. Input-output analysis also traces only market transactions and so does not capture "external effects" like the impact of changes in soil productivity, water quality and air quality which are typically incorporated into benefit-cost analysis. In this study we use the input-output results within the framework of benefit-cost analysis.[1]

Decision Criteria

Another point to remember in interpreting the economic evaluation results is that economic evaluation methods are but one way of evaluating policy options. Other methods include voting and the legal-judicial process. Economic evaluation is simply a method to provide information on relative tradeoffs: what must be sacrificed in terms of things people value in order to implement policy A or project B. It may be that economic tradeoffs are overruled by other values as determined by legal rights or the democratic decision process.

Limitations of Economic Evaluation

Economic evaluation is not a precise discipline. Although one will typically find very specific numeric estimates of values in economic evaluation studies, a great deal of inherent uncertainty always underlies these very exact numeric estimates. In this study, we too have generated exact numeric estimates, but we have generated a range of such estimates to reflect the underlying uncertainty in the estimates.

There are two principle sources of imprecision in estimating economic values. First, estimates of benefits and costs are based on predictions of future impacts. Predicting the future is necessarily uncertain. We have approached this task by generating a number of possible future scenarios and then judging which scenarios are most likely. Reasonable people may disagree with our predictions. We have presented the material which we used to generate scenarios so that those who differ might build alternative scenarios using their best judgement of what the future will be like.

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[1]In the input-output study we looked only at losses to the Washington economy. This is a reasonable approximation to the national losses provided that most changes in the processing industry occur in Washington. In fact a large part of the processing industry is located in Idaho. It may be that losses in Washington are offset by gains in Idaho (or someplace else like Oregon). In this case an approximation of national effects can be gained by using the low impact assumption for the Washington economy impacts.

The second major source of uncertainty in economic evaluation lies in the nature of values themselves. Economic value judgements, like other human value judgements, do not reflect some physical characteristic of nature that can be precisely measured. Values reflect subjective mental states. Economic estimates can be somewhat misleading because they can be presented with numeric precision down to the last decimal place. Indeed, when we investigate specific scenarios under specific value assumptions we take care to make sure our numeric calculations are exact. This numeric exactitude serves to maintain consistency and rigor. But ultimately all values rest on the unknowable inner experience of individuals. Even market prices, the talisman of economic values, are fuzzy; they change with changing income, tastes, and other shifts in circumstances.

Fortunately, the legislative mandate is not to estimate the exact benefits and cost of the proposed policy. Rather it is to estimate probable benefits and costs of the policy. Our estimates of probable benefits and costs follow.

Probable Cost Estimates

Introduction and Scenarios

We estimated probable costs of $5.6 million with a probable range from about $3.9 to $7.9 million. In this section we describe how we estimated these costs. The detailed studies on which these estimates were built are describe in the attached technical appendices.

Probable economic costs of the proposed rule stem from the limitation on grass seed field burning. Limitations on grass seed field burning reduces returns for grass seed farmers. Farm losses may come from reduced bluegrass yields, increased costs, or the reduced returns from an alternative crop. Besides these direct farm income losses, costs include environmental costs due to increases in soil loss from wind and water erosion, losses in the seed processing sector, and losses in jobs and income in the wider community. Other costs include emotional costs to those who lose jobs or suffer business losses, potential changes in farm accident rates due to changes in farm practices, and the costs of administering the program.

Our estimation of costs was based on two major sub-studies: one estimating changes in farm level costs and returns and environmental costs (Painter, Technical Report B), and the other study estimating the impacts that reduced farm production and spending would have on the rest of the economy, particularly the seed processing industry (Holland and Willis, Technical Report A). These studies are described in more detail in separate appendices.

Since there is uncertainty about the impact of the proposed rule, our estimation of probable costs began by examining a number of possible scenarios for the impact of the rule. We began with three scenarios in which bluegrass was replaced on all the affected acres (two-third of the total), half the affected acres (one-third total), and none of the affected acres. In preliminary studies these were termed the high, medium, and low impact scenarios based simply on the number of acres affected. Analysis of the total loss and no loss (high and low impact) scenarios can be found in the technical reports. Our final cost estimates were based on the medium impact or half-out scenario.

Beginning with these baseline scenarios we also explored a number of additional scenarios. In some scenarios prices changed to reflect the impact of reduced supply. In other scenarios markets were assumed to have emerged for grass straw. In still others the impact of changing farm technologies was examined. A totally separate cost estimate was derived from survey data. From these scenarios a wide range of possible cost impacts emerged. Our potential cost estimates ranged as low as $1.4 million to as high as $14 million. However, many of these scenarios were unrealistic--but useful for examining specific impacts. We chose two scenarios as most representative of the likely outcome of the proposed rule and these set the probable range of costs. A final, best estimate was based on the most realistic features of these two benchmark scenarios. We describe these scenarios next.

Half-Out Scenario

For what became the high end of our probable cost range we used the scenario in which one-half of the affected acres are switched from bluegrass production into alternative land uses.[2] This outcome would imply significant environmental costs because about 20,000 acres is switched from bluegrass into alternative rotations or out of production altogether. This outcome would also cause economic losses in the processing industry unless the grass seed were replaced by production from other areas. We assume some replacement--which mitigates some of the economic damages but also means that the costs of smoke are shifted to other areas.

We adopted this "medium" or half-out scenario as one representation of probable costs because our farm analysis showed it to be a likely outcome. In irrigated areas farmers have profitable alternatives to blue grass so that they are likely to change crops as the costs of bluegrass production increase. Our estimates are that about one-third of bluegrass is from irrigated acreage. Farmers in dryland areas have fewer good alternatives. Therefore, many of them are likely to keep most of their blue grass in production even if they have to use more expensive non-burning technologies. Assuming that some of the dryland bluegrass acreage will move to other land uses, the half-out scenario appears to be a likely outcome under current technology. Moreover, price sensitivity analysis confirms this judgement. Reduced bluegrass production will lead to higher prices unless that production is replaced. A modest increase of five percent will make it profitable to keep more than half of the blue grass in production even using current high cost non-burning residue removal technology. The cost we report here is based on the assumption of no price impacts.

[2]In preliminary studies this was called a medium impact or moderate cost scenario because it was halfway between the extremes of all affected fields switching out of bluegrass on the one hand and none of the fields switching to alternative uses on the other.

Rotational Burning Scenario

Past evidence suggests that farmers and the agricultural industry often adapt creatively to new conditions. Economists logic suggests that when prices and conditions change, producers and consumers change their behaviors. Experience and ex-post studies have shown that farmers are usually better adapters than researchers give them credit for. Often the yield and economic impacts predicted by researchers do not emerge because of innovation by farmers and the farm supply industry (Moore and Villarejo).

We modeled a scenario in which behavior changed in response to adoption of the proposed rule. We used a rotational burning scenario to represent such innovative behavior. In rotational burning farmers burn their bluegrass fields every other year. This works out to two years in a six year rotation when non-burning in the establishment and final year of harvest are taken into account. Table 2 shows how such a rotational pattern would work. The fields are divided into six areas--one for each year of rotation including the establishment year. In practice the transition to rotational burning may involve some yield losses or need to burn additional acres in the first year if permits were available through trade or exemption. The reason for the potential yield losses is that, based on past history, some fields may be due to be brought out of rotation sooner than scheduled according to the table below. For instance, in the extreme case a farmer might have had all his bluegrass in the final year of a rotation just before the rule took effect. All his fields would look like field one on our chart. He would have to make some adjustments (either keep a field in an extra year, or burn out of sequence) in order to get his fields into the rotational sequence.

Table 2. Rotational Burning

Year	Field 1	Field 2	Field 3	Field 4	Field 5	Field 6
1	establish	non-burn	**burn**	non-burn	**burn**	non-burn
2	non-burn	establish	non-burn	**burn**	non-burn	**burn**
3	**burn**	non-burn	establish	non-burn	**burn**	non-burn
4	non-burn	**burn**	non-burn	establish	non-burn	**burn**
5	**burn**	non-burn	**burn**	non-burn	establish	non-burn
6	non-burn	**burn**	non-burn	**burn**	non-burn	establish
7	new crop	non-burn	**burn**	non-burn	**burn**	non-burn
etc.	etc.	etc.	etc.	etc.	etc.	etc.

Rotational burning has the benefit of avoiding the sharp yield declines of the later years of the rotation. It also allows the farmers to keep their fields in bluegrass for longer so that they can recoup the establishment costs when no harvest is produced. So, in the rotational burning scenario yields decline (we estimate 30 percent in each of the two years preceded by non-burn residue removal for an average of about 12 percent over the five years of production) but very little bluegrass acreage is lost. Therefore, environmental impacts and effects on jobs and the processing industry are minimal.

Most Probable Cost Scenario

The above two scenarios bracket what we think are probable costs. Some innovative scenario like the rotational burning scenario is highly probable, but its actual nature is unknown. Therefore, the cost estimates are imprecise. On the other hand, the half-out scenario is more exact because the costs are based on what is known to be feasible under current technology and farming practices. However, the cost estimate based on the half-out scenario is also probably an overestimate because some kind of adjustment will take place. Since the half-out scenario is based on a continuation of current trends with only the increased cost of residue removal, it is probably a good representation of what will happen in the short run while the industry adjusts to new conditions. However, the most realistic assumption for the medium and longer term is that the bluegrass industry will adapt to a large degree, but that some bluegrass production will be lost nonetheless. It is also probable that there will be some increase in bluegrass seed prices but, to be cautious, we assume none.

To approximate the most likely outcome we estimated a scenario in which half of the affected acreage switches out of bluegrass, but the acreage remaining in bluegrass adopts an innovative technology like the rotational burning cultural practice. This scenario is built up from pieces of other scenarios we modeled and reported in the technical reports. It does not appear as a separate scenario in the technical reports.

In summary, our final estimates are based on three scenarios. One scenario continues production of bluegrass in all areas but at reduced yields (an average of about 12 percent lower over the six-year rotation) under innovative management systems. A second scenario assumes that one half of the affected blue grass goes out of production and land moves to other uses. (One-half of two-thirds means that one-third of the original total of about 60,000 acres will go out of bluegrass production). The most likely estimate is based on adoption of innovative farm practices, but with a loss of one half the affected acres so that environmental and processor and other economic impacts remain.

Table 3 and 4 show our calculations of probable costs. Table 3 shows estimates of the three scenarios under the baseline rule and Table 4 shows estimates including the exemption and trading version of the rule. (The final results shown in Table 1 in the Summary are essentially a condensed version of Table 4.) Table 4 shows the estimated costs for the alternative version of the rule that includes a 5 percent exemption for land that is deemed extraordinarily difficult to cultivate using alternative (non-burn) technologies and a provision allowing growers to trade burn permits within local jurisdictions. Under this rule, fields that were certified by a conservation official as being extraordinarily difficult to cultivate would be given an exemption--with exemptions limited to 5 percent of the fields. Adoption of the alternative version of the rule reduced costs by about $300,000 on the best cost estimate compared to versions of the rule that include no exemption. (Analysis of the basic version of the rule can be found in the full report

Table 3. Base Rule Cost Estimates ($1000s)

Cost Category	Rotational Burn Scenario			Half-out Scenario			Best estimate			Comments
	Direct Costs	Potential Costs	**Estimated Costs**	Direct Costs	Potential Costs	**Estimated Costs**	Direct Costs	Potential Costs	**Estimated Costs**	
1. Farm level costs:										
Lost income	$3,030	$3,030	**$3,030**	$5,150	$5,150	**$5,150**	$3,510	$3,510	**$3,510**	**100% productivity loss**
Lost employment	$0	$0	**$0**		$340	**$170**		$340	**$170**	50% job loss
2. Environmental cost:										
Soil loss, clean-up, AQ & WQ	$30	$30	**$30**	$300	$300	**$300**	$300	$300	**$300**	$15/acre lost bluegrass
3. Direct processing										
Lost income	$0	$0	**$0**		$300	**$270**		$230	**$207**	90% lost productivity
Lost employment	$0	$0	**$0**		$480	**$240**		$370	**$185**	50% job loss
4. Rest of the economy:										
Lost income		$600	**$360**		$1,300	**$780**		$660	**$396**	60% productivity loss
Lost employment		$960	**$192**		$2,110	**$422**		$1,350	**$270**	20% job loss
5. Other costs:										
Shifted smoke costs	$0	$0	**$0**	$324	$324	**$324**	$324	$324	**$324**	
Administrative costs			**$160**			**$160**			**$160**	two FTEs
Emotional losses			**$230**			**$484**			**$323**	5% penalty
TOTALS	$3,060	$4,620	**$4,002**	$5,790	$10,320	**$8,292**	$4,150	$7,100	**$5,857**	

Table 4. Alternate Rule Cost Estimates ($1000s)

Cost Category	Rotation scenario			Half out scenario			Best estimate			Comments
	Direct Costs	Potential Costs	**Estimated Costs**	Direct Costs	Potential Costs	**Estimated Costs**	Direct Costs	Potential Costs	**Estimated Costs**	
1. Farm level costs:										
Lost income	$3,000	$3,000	**$3,000**	$4,960	$4,960	**$4,960**	$3,385	$3,385	**$3,385**	100% productivity loss
Lost farm employment	$0	$0	**$0**		$320	**$160**		$325	**$163**	50% job loss
2. Environmental cost:										
Soil loss, Clean-up, A & WE	$0	$0	**$0**	$300	$300	**$270**	$300	$300	**$270**	$15/acre lost bluegrass
3. Direct processing										
Lost income	$0	$0	**$0**		$280	**$252**		$215	**$194**	90% productivity loss
Lost employment	$0	$0	**$0**		$450	**$225**		$350	**$175**	50% job loss
4. Economic costs in the rest of the economy:										
Lost income		$600	**$360**		$1,150	**$690**		$540	**$324**	60% productivity loss
Lost employment		$960	**$192**		$2,040	**$408**		$1,310	**$262**	20% job loss
5. Other costs										
Shifted smoke costs	$0	$0	**$0**	$324	$324	**$324**	$340	$324	**$324**	
Administrative costs	$160	$160	**$160**	$160	$160	**$160**	$160	$160	**$160**	Two FTEs
Emotional losses			**$228**			**$460**			**$306**	5% emotional loss penalty
TOTALS	$3,160	$4,720	**$3,940**	$5,760	$10,000	**$7,909**	$4,185	$6,925	**$5,562**	

and the technical appendices.) This rule will also reduce benefits, but our benefits estimates were not finely tuned enough to estimate the value of this variation of the rule.

The benefits from trading were not explicitly estimated due to lack of appropriate data. The benefits of trading are that, once the overall desired limit on burning is set, farmers are able to increase efficiency--"fine-tuning" their farming by using burned bluegrass on the fields most productive under burning. Since we modeled farms in only two broad classes, irrigated and dryland, we were not able to capture the efficiencies that result from shifting burning from one field to another with different productivity and farming cost characteristics. We therefore expect costs lower than those reported here under the alternative version of the rule. In principle the trading provision will not decrease benefits because it does not change the overall level of burning. However, in practice it is possible that some fields will be burnt that would otherwise not be burned. For instance, if a farmer had most of his bluegrass fields in a rotation (establishment, "take-out" year) where he did not need to burn he might sell his permit and thereby increase the total burn.

It is also important to note that the impact of the trading permit will depend, among other things, on the scope of area for the rule. If permits were tradable across all of eastern Washington it is likely that irrigated farmers would sell permits to dryland farmers, especially those in the Spokane area. Such a version of the rule would reduce the benefits of the rule, perhaps substantially. It is therefore assumed here that trading will be within local jurisdictions only. (We could estimate the cost reductions of trades from irrigated fields to dryland fields since we modeled them separately. We didn't estimate these cost reductions because of the assumption of local trading only.)

Direct Farm Costs

Direct farm level losses comprise the majority of the losses in all three scenarios. Direct farm losses are calculated as reductions in returns to management, capital, and land.[3] (See Technical Report B for details.) The cost of variable inputs, capital, and labor are subtracted from revenues. These returns may be distributed as profits to farm operators, rents to landlords, mortgage payments, or taxes.

The basic cost of any reduction in allowable grass seed field burning is the cost of lost farm level production. Our primary method for estimating farm level financial costs was the farm budget approach. Budgets were based on the history of farm budget research done at WSU, particularly bluegrass budgets based upon a multi-state research project entitled "Bluegrass Seed Production Without Open Field Burning" currently underway at Washington State University, the University of Idaho and Oregon State University on non-burning methods for producing both dryland and irrigated Kentucky bluegrass (STEEP project #PSES 061-K534). Enterprise budgets for

[3]These are called economic rents or quasi-rents (producer surplus) in economic jargon.

producing common and proprietary varieties of Kentucky bluegrass were developed in close coordination with growers for both irrigated and dryland production (Hinman, personal communication). Budgeting of the costs for the new technologies which would be used to replace burning was based on the best available equipment costs, but such costs could change when the machinery goes into production. (Usually mass production of equipment leads to lower prices. In this case it may be that the equipment is so specialized it never gets mass produced.)

Typical yields were determined using results of three years of on-farm field trials as well as input from growers. The bluegrass price is based on the 1991-1995 average price and the typical differential for proprietary varieties.

The total cost will depend on the bluegrass seed acreage affected. The exact acreage of bluegrass currently under cultivation is unknown. There are about 40,000 acres permitted for burning. Washington Agricultural statistics also reports about 40,000 acres of bluegrass. However, these official figures appear to be underestimates. By using the higher of the acreage from 1996 burn permits or the amount of acreage reported in bluegrass acreage as part of conservation plans we could document about 54,000 acres. However, information from seed processors indicates that there may be even higher acreage. We based a final estimate of acreage on the documented 54,000 acres adjusted upwards based on the information from processors. We have used 60,000 acres of planted bluegrass in this study. Although this is more acreage than we can document, it is more consistent with the information from seed processors than lower estimates would be.

Farm budget analysis was done separately for irrigated and dryland farms due to a large number of differences between the two farming systems. Irrigated farms are generally on more level ground, have more consistent yields, and usually use proprietary seeds which often command a price premium. Dryland bluegrass farm systems are often on the steeper, more erodible and more difficult to farm ground, and have more erratic yields and generally use common bluegrass. The results of the two separate estimates were then combined for the total estimates.

As noted above, a wide variety of scenarios about the future were budgeted. (See technical report.) Table 5 summarizes some of the key farm budget scenarios estimated. The first budget (A) is a somewhat simplified budget designed to be consistent with the input-output analysis.

Half-Lost Scenario

The half out, fixed price scenario (A) is the basis for our estimates of the high range of probable costs. In this scenario a total of approximately one-third of the land remains in burned bluegrass, one-third goes to wheat, and one-third goes to non-burn technology bluegrass (compared to the

Table 5. Farm Returns

Scenario/Estimate	Lost Grass Acres	Lost Farm Returns: Base Rule	Lost Farm Returns: Alternative Rule
A. Half-out scenario (fixed prices, wheat replace bluegrass)	20,000	$5,533	$5,143
B. Flex price, flex rotation scenario (price up 5%, best crop replaces bluegrass)	27,333	$4,267	$3,835
C. Rotational burning scenario	0	$2,997	NA
D. Other scenarios			
D1. Rot burn + $15 subsidy	0	$2,671	NA
D2. Rot burn + straw market	0	$2,128	NA
D3. Rot burn + subsidy + mkt	0	$1,803	NA

original, pre-rule situation). Also 10 percent of the one-third that goes out of bluegrass, (3 percent of the total) is idled altogether. Although this idled land will probably be used for pasture it is assumed to generate no net returns. Returns to farms drop for three reasons. Costs of non-burn technologies are higher; returns to land in wheat are lower than returns to bluegrass (idled land brings no net returns); and yields in non-burn bluegrass are lower. The cost increase in no-burn bluegrass is due to the higher costs of mechanical thatch removal and the costs of straw disposal. (See technical report for details.)

This half-out scenario is unrealistic in two ways. Irrigated bluegrass farmers are modeled as switching to wheat rather than to their most profitable rotations. (For dryland farmers wheat is generally the most profitable rotation.) It was also assumed that prices would not change in order to be consistent with input-output modeling. However, indications are that bluegrass is price responsive (Folwell). If supply declined, prices would increase. This would increase returns to the remaining bluegrass and would attract some of the lost acreage back into bluegrass production. Indeed this is a more realistic outcome we have modeled as the flexible prices scenario (B).

Although the half-out scenario is unrealistic, it was chosen to represent the higher range of potential farm costs because of its consistency with the input-output model. It also produces production estimates that are consistent with a more realistic model in which irrigated farmers switch to their next most profitable crops and bluegrass prices rise a modest 5 percent. However, the price increase and opportunity to use the best rotation in the best rotation, flex price scenario (B) reduce farm losses by about $1 million compared to our base scenario--indicating that we are

are probably overestimating costs somewhat. This is one reason we designate the base half lost scenario to be the high end of the probable costs.

In preliminary studies we examined alternative assumptions about the direct impact on farmers of reducing bluegrass acreage. In one scenario farmers are assumed to continue to grow the same quantity of bluegrass as before the rule, but the affected two-third acres will all be produced using alternative, non-burn technology. In another fixed price, wheat rotation scenario we examined what happens if all the affected acres (two-third of total) go out of bluegrass production. These scenarios allowed us to test the impact on the economy and the processing sector of the extreme assumptions of no lost acreage or all affected acres lost. See the technical report for details.

In the next farm budget (B) we test the effect of price changes and allow farmers to choose the best alternative rotations. This and similar scenarios we explored are more realistic at the farm level because they are based on what farmers could do to make the highest possible profit (or lowest losses) in each case. In these scenarios the high costs of alternative, non-burn thatch/straw removal tends to drive production of bluegrass out. However, research shows that bluegrass prices are quite sensitive to changes in supply (Folwell et al). Reductions in bluegrass production will induce higher prices which in turn will attract some farmers back into production. How much of a price reaction there will be depends on how much reductions in Washington bluegrass is replaced by bluegrass elsewhere. Based on the history of grass burning restrictions in Oregon and the increasing attention the Environmental Protection Agency is giving to particulate pollution, it is highly probable that areas outside Washington will also be subject to restrictions on burning which will prevent other areas from replacing all Washington bluegrass.

In addition to the 5 percent price increase we examined scenarios using a 15 percent price increase and no increase in price together with flexibility in choosing the best rotation. See the technical report for details. As noted above, returns to farmers improve compared to the case when they were forced to switch to wheat and prices remained constant. It is possible that a sufficient price rise would compensate farmers for the higher cost of using non-burn technology. In the 15 percent price rise scenario (discussed in technical report) irrigated farms actually gain relative to the pre-rule situation, though dryland farms still lose and overall farm losses are reduced to about $2.3 million.

The next scenario, C, is the rotational burn, adaptation scenario described above. We examine the possibility that farmers would creatively adapt to the burn regulation and determine efficient and profitable ways to farm.

A final group of scenarios (D) examined some possibilities for mitigating farm losses. For instance, the financial impacts on farmers might be mitigated if markets for bluegrass straw appeared or if the costs of straw removal were compensated by the public sector. The budgets in section D illustrate the impacts of the possibility that a market for bluegrass straw would develop or that subsidies would be provided to bluegrass farmers to compensate for their losses. We did not include these mitigating features in any of our final estimates, but the data indicates that farm losses can be reduced by up to about $1 million.

Agricultural Job Losses

Returning to tables 3 and 4, we next examine losses to agricultural labor. Tables 3 and 4 show potential and estimated costs of job losses. As discussed above, Benefit Cost studies usually do not count the secondary loss of jobs and the ripple effect of lost income in the rest of the economy.[4] However, in this case we used a regional economic impact model to include probable job and business losses in our analysis.

We used the input-output model (see appendix) to estimate potential losses of jobs in the farm sector. The input-output model estimates potential job loss. The number of jobs lost is a potential rather than an actual job loss because the model assumes all those who lose employment at one farm will never get a job the rest of their life (or more accurately, the rest of the model life). The actual job loss depends on how many and how quickly those who lose jobs are re-employed. Records for unemployment compensation claims from the Washington Employment Security Division show that most farm workers who lose jobs are re-employed fairly quickly. However, much of this quick re-employment reflects the large short-term work in agriculture. We assume that some of the lost jobs are going to be for the more permanent "hired hand." Since workers in rural communities tend to be more place bound and the job market more restricted we assume that 50 percent of workers remain permanently unemployed.

Note also, that the job losses counted in the model are net losses. The model calculates the number of jobs lost in switching out of bluegrass and the number gained jobs gained from replacing bluegrass with say, wheat production. Thus, if a farm replaces bluegrass with wheat and keeps the same level of hired labor it will show up as no change in jobs.

We estimated no change in employment in the rotational burning scenario. If anything, the use of non-burn technology might add some employment to the bluegrass sector though our model picked up none. In the half out and most probable scenarios we estimate some net job loss. If about half of these workers find jobs, then the economy will suffer a loss of about $170,000 due to these lost agricultural jobs in both scenarios.

Environmental Costs

Returning to Tables 3 and 4, the next category is environmental costs. Bluegrass is used as a cover crop to prevent soil erosion. Replacing bluegrass with other crops will generally increase

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[4]See also discussion below concerning economic impacts and the input-output technical report appendix.

soil erosion (both water based and wind erosion) although in irrigated areas bluegrass may sometimes be replaced with alfalfa, another good ground cover. Farmers bear some of these costs in the form of reduced future productivity and costs of cleaning up on-farm ditches. Other costs are incurred by the local community including the cost of cleanig sediment from ditches and the environmental impacts of lower air and water quality.

Environmental costs are shown in Table 6 with the affected acreage for the three probable estimate scenarios. Environmental costs were estimated separately for irrigated and dryland areas.

Table 6. Environmental Costs

Scenario/ estimate	Lost Bluegrass (Acres)	Environmental Costs ($1,000s)
Rotation scenario		
Base rule	2,000	$30
Alternative rule	0	$0
Half-out scenario		
Base rule	20,000	$300
Alternative rule	18,000	$270
Best estim. scenario		
Base rule	20,000	$300
Alternative rule	18,000	$270

Environmental costs for dryland areas were estimated as the sum of costs for cleaning-up dirt due to increased off-site run-off from eroding fields; a value for impacts on water quality; and a value for the potential for lost future production due to the loss in soil from increased erosion. Only the clean-up costs for ditches has a market value, the other environmental costs are non-monetarized. Estimation of non-monetarized values require specialized techniques such as the survey based valuation technique we used in this study to estimate benefits of reduced smoke. Since additional non-market studies were beyond the time and resources of this study we used environmental values from other studies. Most studies measuring the value of erosion control have used a value between $1 and $5 per ton of top soil eroded. We used $5 per ton of erosion, a value on the high end of those found in the literature. Based on an average of 3 tons per acre of erosion from dryland wheat, we estimate environmental costs of $15 per acre in Spokane county and we have used the same figure elsewhere. See the technical appendix for more details on these calculations.

In the irrigated areas, wind erosion is the major environmental concern. Wind erosion is extremely variable, depending on location and crop cover. In some cases bluegrass might be replaced by alfalfa which would cause little or no change in wind erosion. However, fields switched to other crops may experience quite large increases in soil loss, since wind erosion varies from 4 to 21 tons per acre for Columbia Basin row crop rotations. But we have no concrete data on what change in erosion will come from switching out of bluegrass. We also have no values for the per acre or per ton value of the wind erosion. In the absence of any specific information on wind erosion quantities or values we used the same $15 per acre for environmental losses in the irrigated areas as we used in the dryland areas.

Tables 3, 4, and 6 show that environmental costs are minimal for the rotational burn scenario because the bluegrass industry keeps about the same amount of land in bluegrass. In the half-out and best estimate scenarios about 20,000 acres of bluegrass are lost leading to environmental damages of about $300,000 in the base rule. For the alternative rule allowing exemption and trading 18,000 acres are lost for a cost of $270,000.

Direct Processor Costs

The next two cost items in Tables 3 and 4 are the economic costs to the processor industry due to the reduced supply of bluegrass seed. Tables 7 and 8 show the economic impact effects to the farm sector, processors and the rest of the economy in isolation for ease of reference and comparison to the data in the summary and technical reports. The potential cost numbers are what appear in the technical appendix describing the input-output models. The summary of the estimated costs for each category are what appears in the summary report.

Lost production will mean reduced supply of raw materials for seed processors. The impact on seed processors will depend on whether or not the reduced supply of raw material can be made up from other sources. We assumed that about half of lost seed supply would be made up by other sources.

In the rotational burning scenario the bluegrass seed processing industry suffers no direct losses because bluegrass production is maintained at almost the same levels as before the rule. In the half out and best estimate scenarios, losses will result from any reduced supply to the processing industry.

Table 7. Base Rule Economic Impact Estimates ($1000s)

Cost Category	Rotation Scenario		Half-out scenario		Best estimate		Comments
	Potential Costs	**Estimated Costs**	Potential Costs	**Estimated Costs**	Potential Costs	**Estimated Costs**	
1. Farm level costs:							
Lost farm income	$3,030	**$3,030**	$5,150	**$5,150**	$3,510	**$3,510**	100% of direct costs
Lost employment	$0	**$0**	$340	**$170**	$340	**$170**	50% job loss
Sub-total	$3,030	$3,030	$5,490	$5320	$3850	$3680	
2. Processing sector							
Lost processor income	$0	**$0**	$300	**$270**	$230	**$207**	90% lost productivity
Lost employment	$0	**$0**	$480	**$240**	$370	**$185**	50% job loss
Sub-total	$0	$0	$780	$510	$600	$392	
3. Rest of the economy:							
Lost business income	$600	**$360**	$1,300	**$780**	$660	**$396**	60% loss productivity
Lost employment	$960	**$192**	$2,110	**$422**	$1,350	**$270**	20% permanent job loss
Sub-total	$1560	$552	$3,410	$1,202	$2,010	$666	
TOTALS	$4,590	**$3,582**	$9,680	**$7,032**	$6,460	**$4,738**	

Table 8. Alternate Rule Economic Impact Estimates ($1000s)

Cost Category	Rotation Scenario		Half-out Scenario		Best Estimate		Comments
	Potential Costs	**Estimated Costs**	Potential Costs	**Estimated Costs**	Potential Costs	**Estimated Costs**	
1. Farm level costs:							
Lost farm income	$3,000	**$3,000**	$4,960	**$4,960**	$3,385	**$3,385**	100% of direct costs
Lost employment	$0	**$0**	$320	**$160**	$325	**$163**	50% job loss
Sub-total	$3,000	$3,000	$5,280	$5,120	$3,710	$3,548	
2. Processing sector							
Lost processor income	$0	**$0**	$280	**$252**	$215	**$194**	90% lost productivity
Lost employment	$0	**$0**	$450	**$225**	$350	**$175**	50% job loss
Sub-total	$0	$0	$730	$477	$565	$369	
3. Costs in the rest of the economy:							
Lost bus. income	$600	**$360**	$1,150	**$690**	$540	**$324**	60% loss productivity
Lost employment	$960	**$192**	$2,040	**$408**	$1,310	**$262**	20% job loss
Sub-total	$1,560	$552	$3,190	$1098	$1,850	$586	
TOTALS	$4,560	**$3,552**	$9,200	**$6,695**	$6,125	**$4,503**	

Impacts to the processing industry fall in the class of things that are not generally counted in benefit-cost analysis. It is generally assumed that the value of the loss in production is fully captured by the loss in the output of the good, valued at its selling price. However, if the processing plant and associated jobs lost are not re-employed, than the opportunity cost of losing the productivity of these resources should be counted according to economic logic. We therefore calculated potential losses to the processor industry and workers. Enterprise budgets were calculated for processors using the same kind of assumptions as are used in the farm enterprise budgets. These enterprise budgets are used as the basis for calculating direct losses to processors. Additional details can be found in the economic impact technical report.

In economic terms losses of business capital should be counted as quasi-rents, that is, lost returns to a fixed factor as long as the factor would have had a viable economic life. Worn out, depreciated, or obsolete equipment has no economic value and so cannot be "lost."[5] In an industry like grass-seed processing, the equipment is specialized and has a long lifetime. Therefore, we counted a fairly high proportion of the lost potential returns to processors as economic losses. If one assumes that the grass-seed processing plant has a useful life of about 15 to 20 years and one looks at effects in the medium term, than the grass seed plant still has most of its economic life left. We assume 90 percent. We assumed that labor in the processing industry is like labor in the farm sector and that 50 percent would be re-employed--leaving an estimated cost of 50 percent of the potential job costs.

Impacts on the processing industry also depend on how much of the seed supply can be replaced. Our estimates are based on the assumption that the seed processors are able to replace about half of the lost Washington seed from other sources, most likely bluegrass farmers in Idaho.

The losses also depend on which version of the rule is adopted. The more flexible alternative version of the rule would mean that less supply is lost to the industry. In the alternative rule, half-out scenario the seed processing sector potential losses are about $280,000 in lost returns to capital and management and $450,000 in lost employment. Using the 90 percent and 50 percent medium term unemployment assumptions the result is estimated losses of $252,000 and $225,000 for income and job losses. Estimated losses are $194,000 and $175,000 for the best estimate scenario.

Other (General) Economic Costs

The reduced economic activity in the bluegrass growing and processing sectors can lead to reduced economic activity elsewhere. Total (potential) impacts of a change in final demand include the "ripple" effects of spending in the economy as well as the direct effect on the target

[5]The fact that obsolete equipment cannot be counted as losing business is part of the justification for the usual benefit cost practice of not counting ripple impacts. In the long run all capital must be replaced. Therefore, if one counts costs only after all economic adjustments have taken place, costs to capital disappear--new equipment and new industries would have to be formed as the economy changes anyway.

industry. Each industry buys supplies from other industries and pays its employees and shareholders. A change in bluegrass production and processing industries' sales will result in changes in what they buy from other industries (called indirect effects).

The reduced income to farmers, farm laborers and landlords will also mean lower spending at the local supermarket and restaurant (called induced effects). The owners and laborers of the firms have lower household incomes leading to fewer purchases in the consumer markets. The "ripple" or secondary economic effects (indirect and induced) may be made up by compensating growth in other parts of the local economy. Or there may be permanent reductions in the local economy which are, however, partly offset by increases in the economies of other regions.

In our cost estimates for the general economy we assume 80 percent of the labor released because of bluegrass production will be rehired, and 20 percent will remain unemployed. Capital is less flexible than labor. We assume that 60 percent of the capital in the general economy remains unemployed. In the general economy, business turnover is more rapid than in a specialized industry like grass seed. We use the 60 percent loss figure in the general economy to reflect both the greater flexibility of business opportunities and the shorter useful life of investments. In the general economy a five or six year useful life is common. We based our 60 percent loss on a medium term which includes about three years of lost capital productivity out of a typical business investment life of five years. In a longer run analysis--six or more years from the rule implementation, most businesses will have adjusted or have been replaced in the normal pattern of economic change. In such a longer run we would count business losses at zero.

We count potential impacts of $1.56 million and estimated impacts of $552,000 in the rotational burning scenario divided between losses in returns to capital (business profits) and lost income due to lost jobs. In the half out scenario $3.19 million in potential impact are divided between $1.15 million in lost business income and $2.04 million in lost jobs. Adjusting for re-employment brings an estimate of about $690,000 in lost business income and $408,000 in lost jobs. The potential impacts for the best estimate scenario are about $1.85 million and the estimated impacts are $324,000 in lost business income and $262,000 in lost jobs for a total of $586,000.

Other Costs

An additional cost is due to the shifting of smoke damages if part of the lost production of bluegrass is made up by bluegrass seed produced elsewhere. We assumed that about half of the lost bluegrass seed will be replaced by Idaho farmers and that about half of that will be replaced in the Coeur d'Alene area. Therefore the benefits these areas will receive from reduced smoke from Spokane county growers will be partly offset by increases in smoke from local growers who step in to fill the demand for seed.

Another cost is the lost utility or "pain and suffering" of people who lose a job or suffer business losses. While in principle such losses should be included, they are, however, rarely included in economic analyses due to the lack of reliable data. We found no data relevant to the current study. To partly compensate, we added a penalty of 5 percent of job and business losses to account for the emotional costs of the proposed rule. We added this to the "potential" jobs and income losses to include even those who, for instance, lose a job and then get rehired fairly quickly. We also used high end estimates of job loss and business losses. For instance, in the general economy of Washington the current unemployment rate is about 5 percent. We assumed that 20 percent and 50 percent of general and local labor respectively would remain unemployed.

Another cost is for administration of the rule. We included $160,000 in administrative costs in all scenarios based on personal communication with the Department of Ecology. This amount is based on an estimated two FTE (Full Time Equivalent) including overhead and associated costs. This presumes about one full time person and another FTE of periodic effort by other personnel (for example, six people working for two months would be one FTE).

Another potential cost is the change in accident rates for farmers as they change production practices. Farming is a high risk occupation and changing practices would change accident rates. However, we found no concrete data on which to base costs of this change. We looked at accident reports, but could not find a pattern we could apply to the expected changes in farming practices so this potential cost remains unquantified. Conceptually, it could be measured as the increase in health, accidental death and dismemberment (AD&D) and, especially, long term disability insurance costs to farmers from the change in production processes. In summary, although any specific accident may have high medical and emotional costs, we found the potential monetary value of such costs low compared to the other costs, based on actuarial (insurance costs from changes in the probability of an accident) calculations.

For illustrative purposes we examined the change in disability insurance costs for a 50 year old farmer with a net income of $50,000 per year. Such a farmer might pay about $2,300 per year premium for coverage of $33,000 of his or her income (the insurance companies generally do not insure the full income of farmers). This premium includes a surcharge of about 25 percent over a standard premium to reflect the extra riskiness of farming. Suppose the change in bluegrass farming practices increased the risks of farming by nearly 40 percent--that would work out to an increase of 10 percent in the annual disability premium. Calculating 200 farmers at 10 percent of $2,300 per year, one comes up with an estimate of $46,000 per year for the actuarial value of the increase in risk from changing farming practices. We did not include this figure in our estimates because we did not have the data to estimate the actual change in risks. The purpose of the illustration is to show that the change in risk has a relatively small actuarial value.

WTP (Survey-Based) Cost Estimate

In general, cost estimates assume a compensation perspective--what amount of income would be required to replace the income lost by farmers or processors.[6] A completely different way to estimate costs would be to ask those who might be injured by a reduction in bluegrass field burning how much they would pay to retain the right to burn bluegrass seed fields. This is exactly analogous to the approach used on the benefit side to estimate total benefits by survey. Economists expect that willingness-to-pay value estimates will be lower than compensation perspective estimates. People are limited by their incomes in how much they can pay, but they may accept any amount. However, in the case of market valued impacts the difference between WTP and compensation perspective estimates is usually small.

We did derive a direct willingness to pay estimate for the amount that people would pay to avoid having restrictions imposed on grass field burning. We included a question in the survey instrument. (The survey instrument was principally designed to estimate the benefits to improved air quality from reduced burning.) We asked those who opposed the proposed rule to reduce burning what they would pay to continue to allow burning. For concreteness we suggested that the payment would go into a fund for compensating those who could show they were harmed by grass field smoke. This question was asked of farmers and non-farm opponents alike.[7]

We obtained a value of about $1.4 million for total costs from this approach. In principle this is what the right to continue to burn is worth to those who wish to keep that right, but our estimate is a very unstable and imprecise value for a variety of reasons. First, very few of the main affected party, bluegrass seed growers, appeared in the survey. (The survey respondents were selected randomly and there are relatively few farmer operators, and specifically, bluegrass farmers in the total population of eastern Washington and northern Idaho.) Also, the overall number of people who offered to pay for continued burning was very small. These small numbers makes it very unreliable to generalize our value to the overall population.

Another factor is that the way we asked this willingness-to-pay question encouraged people to answer in terms of what the thought might be the "right" amount for a contribution to pay for the damages caused by the burning instead of what the right to continue burning is worth to their household. Some people may not have been paying for the continuation of burning -- but making a donation to a group whom they felt obligated to help. Thus, this group of respondents is actually revealing what they think they should pay as there fair share for the damage from

[6]This contrasts with the benefits estimates which were largely based on a willingness-to-pay perspective--the amount of income that people would pay to receive some benefit or avoid some harm

[7]Bluegrass farmers have an obvious personal incentive to pay for the continuation of the open burn, "the right to burn." Presumably non-farmers are paying partly in solidarity with farmers, partly because they want to reduce the general regulatory environment, and partly for humanitarian reasons discussed in the subsequent paragraph.

grass field burning rather than what it is worth to them to have the open burning policy continued.

Probable Economic Benefits

We estimate probable benefits of the rule at between 6.6 to 10.2 million dollars. Our most reliable estimate is that benefits will be about 8.4 million dollars. This is a reliable, but cautious estimate of benefits. For instance, using an alternative, less dependable estimation technique, we estimate potential benefits of between 9 million and 18 million dollars. While these estimates are less reliable than the primary estimate, they suggest that it is unlikely that the primary estimate is overstated.

The largest potential benefit of the proposed rule is improved air quality from reduced smoke emissions. Epidemiological evidence has established a clear link between small airborne particles and health, particularly for an at-risk population comprising people with existing cardio-pulmonary conditions such as asthma, emphysema, chronic bronchitis or heart disease.[8] Additional benefits from the proposed rule include the benefits of traffic accident reductions, enhanced recreational opportunities, reduced dirt and nuisance effects from smoke particles, and the aesthetic effects of improved atmospheric conditions.

Contingent Valuation—Willingness to Pay Estimates

Our principal estimation method is based on directly estimating the value of smoke reduction from the point of view of the average household in the affected area. This method estimates combined health and non-health benefits since households are asked for one value for smoke reduction regardless of the reasons they may wish to have smoke reduced.

To estimate this value we used a standard economic valuation technique called the contingent valuation method. In the contingent valuation method households are asked how much they would be willing to pay (WTP) for implementation of the rule to reduce smoke from bluegrass seed field burning. To get reliable estimates, survey respondents were asked to imagine they were voting in a referendum about whether to approve and pay for the smoke reduction program--the proposed rule. The willingness to pay estimate for the sample is then extrapolated to the overall population of the area.

To obtain this contingent valuation estimate we conducted a scientific telephone survey of a random sample of households in the affected area. Households were randomly selected from

[8]There is also some speculation that the higher rate of asthma found in Spokane compared to other regions may be due to the higher levels of particulate pollution in the Spokane area. Since this possibility is still speculative it was not counted in the study.

telephone directory data banks. The goal of the study was to complete 1,500 interviews comprising two subsamples: (1) 750 completed interviews in Spokane County, and (2) 750 interviews covering other affected areas in Eastern Washington and Kootenai and Bonner Counties in Northern Idaho. The Social Survey Research Unit at the University of Idaho administered the survey. We obtained 1,561 completed surveys.

The questionnaire (contained in a separate technical appendix that can be obtained upon request) contained:

- a section for identifying primary farm operators and asking questions about farm operations and use of field burning as an agricultural practice;
- a section with questions about respondents' perceptions of general air quality and environmental policy;
- a section with questions regarding the health status of household members; this section had follow-up questions for households containing anyone with a chronic respiratory or cardiac condition;
- a section which described the proposed rule to reduce smoke from the burning of bluegrass fields; follow-up questions were asked about perceived benefits or concerns about the rule;
- a section describing the proposed rule and asking the value questions;
- a section with demographic questions (age, income, etc.).

A sequence of questions were used to describe the rule and then elicit the value for measuring the household benefits due to the proposed rule. Respondents were first asked whether they favor or oppose the proposed rule. All respondents, including those in Northern Idaho, were told that the rule only affects smoke from bluegrass fields in Washington. Responses to the referendum question are given in Table 7. It is important to note that this survey was not designed as a voter survey. These survey results do not predict how a popular vote on the proposed rule would actually turn out, although they do give some indication of popular sentiment. Voter surveys include questions designed to predict who would actually vote and have other differences from the survey we conducted.

We also did a statistical analysis of the referendum data to analyze what factors disposed people to oppose or to favor the rule. We analyzed only data from the survey so there may be other factors beyond the scope of the survey which influence opinions on this issue. The model shows that those respondents who favored the rule placed greater importance on:

- health risks to their own household,
- health risks of other households,
- the nuisance caused by smoke and,
- the degree grass smoke contributes to air pollution.

Table 7. Results of Revised Vote Count on the Referendum to Reduce Smoke*

Response	Spokane Co.	Eastern WA	No Idaho	Row Total
Favor Program	374	232	110	716
	(50.1)	(38.9)	(50.2)	(45.9)
Against Program	302	300	80	682
	(40.5)	(50.3)	(36.5)	(43.7)
Other Responses	70	64	29	163
	(9.4)	(10.8)	(13.2)	(10.4)
Column Total	746	596	219	1561
	(47.8)	(38.2)	(14.0)	(100.0)

* Numbers in parenthesis are column percents except Column Total which are row percents.

Respondents who opposed the rule felt the rule

- singled farmers out,
- placed financial burdens on farmers,
- overstated the health benefits, and
- lacked importance compared to other issues.

Also, those with higher incomes tended to vote for the program while residents of Eastern Washington outside Spokane tended to vote against the rule. Details about this analysis can be found in the appendix.

Respondents who favored the rule or who were not sure were than asked whether they would pay to have the rule implemented. (Those who did not favor the rule were asked if they would be willing to pay to continue to allow burning; see earlier discussion.) Also those who would not pay were asked further questions to determine if they truly viewed the rule as having zero value or if they were "protesting." Some people object to the idea of expressing their preference as a monetary value. Others believe that "the polluter should pay." Such respondents clearly have a positive value, but they will not reveal it directly. We used statistical means to estimate values for the "missing values" of people who just did not know how much they would be willing to pay, and for the "protest" zeros. (See Mitchell and Carson for discussion of this problem.)

Our best estimate of $8.4 million in benefits is based on this technique. The range around the estimate is based on the margin of error in extrapolating the benefit value from the sample population to the total population. Our use of a relatively large sample (1561 households) compared to many studies of this type helps to minimize this margin of error.

Epidemiological-Economic Estimates

The alternative benefits estimation method uses an indirect method based only on potential health benefits. This is a two step procedure based on combining epidemiological and economic techniques. We first estimate the potential exposure of the affected population and the resulting probable change in medical and mortality impacts due to the improvements in air quality using the results of epidemiological studies. There is a large epidemiological literature documenting the health effects of small airborne particles. Particles from combustion processes appear to have larger health impacts than ordinary dust particles. The potential impacts of fewer dust particles include: reduced medical costs, reduced loss of wages due to lost work, reduced "pain and suffering" and, most importantly, reduced mortality.[9] Once the potential improvements are identified, they are valued using monetary values. The monetary values for impacts like asthma attacks are obtained from standardized values based on a large number of economic studies. We estimated benefits of between \$9 and \$18 million using this two step procedure.

However, the estimates based on this epidemiological-economic approach are imprecise. We lack detailed information on how the smoke reduced by the rule would reduce the exposure of the affected population. We had to use general estimates of this exposure since the detailed monitoring and smoke modeling necessary to determine exposures have not been done. More detailed exposure knowledge would allow us to make more precise estimates of the health effects because we have very good information on the effects of particulate exposure from the extensive epidemiological literature on the impacts of airborne particles on human health. However, we had to use available estimates of the smoke exposure which means these health cost estimates are imprecise.[10]

It is interesting to note, however, that the estimate of health benefits from reducing smoke actually exceeds the willingness-to-pay estimate. This is a paradox because the WTP estimate is supposed to include both health and non-health benefits. There are several reasons for this apparent paradox. One has been mentioned; the health benefits estimates are imprecise.

A second reason that the WTP estimate may be lower than the health based estimate is that many respondents did not like the fact that the proposed rule to reduce smoke would impose a burden on local farmers. They therefore discounted the value they were willing to pay for the program to account for this negative impact. This can be seen especially outside the Spokane and North Idaho areas. While the majority of households in Spokane and Northern Idaho favor the proposed rule, the majority of residents in other areas of Eastern Washington oppose the rule.

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[9]The health effects of exposure to other constituents of smoke (such as volatile gases) were not estimated. Moreover the possibility that long term exposure to smoke and particles may increase the rate of asthma or of lung cancer were not used because reliable epidemiological estimates are not available.

[10]Another source of variance in the estimates is the assumed cost of mortality. The cost of mortality is the major component of benefits in this approach. We used medium to low estimates for the cost of mortality.

These results imply that the willingness to pay for the smoke production is a net value: it is the value of the benefits of smoke reduction to households less a penalty or cost for the burdens of the program.

Finally, a third reason that the WTP estimate is low is that it measures benefits only from a private perspective. This means that, in evaluating their costs, households consider <u>their</u> costs for, say, hospitalization, but not the cost paid by insurance or government programs. This means that the survey based WTP benefit estimate is likely to be understated because it does not include costs to general businesses and the public. Thus, losses to the recreation industry in Northern Idaho are not included, though the cost of lost recreation days to the individual are included. The health exposure based estimates are also understated because they do not include non-health benefits at all.

Non-Health Benefits

As noted above, the WTP benefits estimate in principle captures health and non-health benefits. In a preliminary review of existing information we explored information on benefits from improved visibility, reduced dust and nuisance, and increased recreational opportunities. Due to the limited time and resources and the inclusiveness of the contingent valuation WTP estimate we did not conduct any original research on these issues. Our preliminary studies indicated that these benefits are relatively small compared to the health effects.

Compensation Based Estimate

Besides the willingness to pay and epidemiological-economic estimates, a third estimate of benefits could be made based on the special assumption that the population affected by smoke has the right to be free of smoke. If they have the right to be free of smoke, they should not have to pay to get reduced smoke, they should be compensated for any damages caused by continued burning. This approach produces much larger estimates of the value of smoke reduction, about $18 to $30 million.

We put less emphasis on these estimates than the other two benefits estimates for conceptual and practical reasons. Conceptually, the question of whether it is the right of farmers to burn their fields or the right of local residents to clean air that should be paramount is a legal and moral question beyond the scope of this study. However, the main reason we put less emphasis on this estimate is that the method used for estimation of compensation is unreliable. We used the same survey to estimate compensation as we did for willingness to pay. However the compensation value is based on a very small number of respondents making it hard to generalize to the whole population, and respondent reporting patterns are less stable for compensation questions giving rise to a great range of individual value estimates. Most economists and government agencies disallow compensation estimates for these practical reasons. For instance, the National Oceanic and Atmospheric Administration disallows compensation estimates based on the recommendations of a blue ribbon panel of economists.

APPENDIX A

THE ECONOMIC IMPACT OF A LIMIT ON GRASS SEED FIELD BURNING: THE WASHINGTON ECONOMY

Technical Report

Submitted to:

Washington State Department of Ecology
Air Quality Program
P.O. Box 47600
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Revised publication version. The version contains format edits and copy edits to the "Estimates" report dated January 7, 1997. Both versions are available for review. No substantive changes were made from the January 7, 1997 version.

Introduction

The purpose of this report is to provide an analysis of the economic impact of reducing grass seed field burning in Washington. The estimates of economic impact summarized in this report were subsequently used to estimate the "economic costs" in the benefit-cost analysis of reduced field burning. The analysis applies specifically to the production and processing of Kentucky Bluegrass grass seed. Many other species of grass seed are produced in Washington, but it is only Kentucky Bluegrass that is critically dependent on field burning as part of the production practice. The tasks associated with this analysis are: (1) to estimate the expected changes in industry supply, income, and employment for both the grass seed growers and the grass seed processing industry; (2) estimate the total effect on economy-wide supply, income, and employment stemming from the direct effects on growers and processors.

The analysis in part (1) relies on farm enterprise budgets that show grass seed yields and production costs under current technology with burning and under future expected technology without burning. These budgets were developed by agricultural economists at Washington State University working in collaboration with other agricultural scientists and grass seed growers. Also important were enterprise budgets representing the grass seed processing industry. The direct economic impact of the limit on grass seed field burning was derived from information contained in the enterprise budgets representing production costs for growers and processors.

The analysis in part (2) as summarized in this document, relies on an input-output model of the Washington economy. The model was constructed from the IMPLAN data system and represents the Washington economy in 1993.[1] The industry accounts in the original model were modified based on the enterprise budget information previously described, in order to more accurately depict the grass seed production and processing industries. The resulting model is able to more accurately capture the direct effect of the field burning restriction on grass seed growers and processors. This is important since accurate economic impact analysis depends mainly on a correctly specified direct effect.

The remainder of this report is organized as follows: (1) the grass seed industry is reviewed in terms of basic structure of the industry and its economic contribution to the Washington economy; (2) the economic impact section reviews the economic assumptions that characterize economic impact analysis and discusses each of the scenarios that characterize possible adjustment of the grass seed industry to the two thirds reduction in grass seed acreage burned; (3) the final section presents the results of the economic impact analysis in terms of the overall cost to the Washington economy of the limit on grass seed field burning.

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[1]IMPLAN is a input-output modeling system that was developed to facilitate the construction of regional input-output models. The IMPLAN data base designed to be used with Micro IMPLAN, an economic estimation tool. The IMPLAN system is the product of MIG, Inc. a firm in Minneapolis, Minnesota.

The Structure and Economic Importance of the Grass Seed Industry

The Kentucky Bluegrass seed industry in Washington has two parts. The growers who produce the seed and the firms that process the grass seed. The grass seed processors buy the uncleaned seed, clean it, sort it, and bag it; and then market the seed to wholesalers, nurseries, and other downstream users. (For a good discussion of the Kentucky Bluegrass growing and processing sectors, see the July 26, 1996 Huckell/Weinman report to the State Department of Ecology.) The purpose of this description is to add to and elaborate on that discussion.

Roughly, 34,500 acres of Kentucky Bluegrass were permitted to burn in 1995, but an industry source estimated total production at 57,000 acres. A recent estimate of acres in production in 1996 (the first year of the burning limitation) places production acres at 60,220 (Painter, 1996) which corresponds closely with the industry estimate of 57,000 acres. This comprehensive figure provided by Painter is the estimate that we use in the following description and analysis.

Assuming **60,220** acres of Kentucky Bluegrass production at an average yield of 530 pounds of clean seed per planted acre results in **31.8** million pounds of total Bluegrass seed production in Washington in 1995 (Table 1). The 530 pound average includes the zero yield in the establishment year. Recent years have seen the development of proprietary varieties of Bluegrass that exhibit special qualities of color, texture, etc., and an increasing portion of the Bluegrass acreage in Washington is allocated to the proprietary varieties. Just how much Washington production is of the common variety and how much is proprietary is not clear from available public sources of agricultural data. The question is important because nearly all proprietary grass seed is grown on irrigated land and involves different yields, product prices, and production techniques than common grass seed which tends to be produced mainly on non-irrigated or dryland.

Based on informal discussions with grass seed processors in Washington and Idaho, we estimate that approximately 35 percent of total grass seed acreage is proprietary and, thus, involves irrigated production practices. (The corresponding Huckel/Weinman estimate was 20 percent.) For practical purposes this means that we assume that 35 percent of Washington Kentucky Bluegrass production (proprietary varieties) is produced under irrigated technology, with the remaining portion of production (common Bluegrass seed) produced under dryland technology.

Accordingly, the total sales value of the Bluegrass production in Washington in 1995 valued at the farm gate is approximately **$22,220,000** (Table 1). The income (employee compensation plus returns to operator labor, land, and management) is estimated as **$11,570,000**. Not all of this seed is processed in Washington. A major processor of grass seed is located in Northern Idaho and our estimate is that about 30 percent of Washington Bluegrass seed supply is exported from the state in unprocessed form (Table 1). This is important regarding the economic impact analysis, because processing income is not generated in Washington from the exported seed.

By the same token, not all the Bluegrass seed that is processed in Washington is produced in Washington. Idaho is an important producer of Bluegrass seed that is imported into Washington for processing. Our estimate is that approximately 25 percent (7,354,000 lbs) of the Bluegrass seed processed in Washington is imported into Washington from other states (Table 1). The amount of imported (from outside Washington) grass seed supply is important to the economic impact analysis. Imported grass seed supply will not be directly affected by the grass seed field burning reduction, but it does generate processor income in Washington. Washington grass seed processors may be able to obtain additional supply from imported sources (Idaho, Oregon) if Washington Bluegrass seed production were to decline.

The processing of Kentucky Bluegrass seed in Washington is estimated to generate **$30,710,000** in total sales of processed grass seed. Income (total returns to labor and capital) from processing is estimated to be **$6,250,000**, with employee compensation accounting for 62 percent of processing income. The direct employment including full time and part time jobs is estimated at **146** jobs.[2] The growing of proprietary Bluegrass seed generates an estimated **$3,400,000** in income and generates **101** full and part time jobs. Common Bluegrass seed production is responsible for **$8,170,000** in Washington State income and **170** jobs (Table 1).

Table 1. Economic Aspects of the Kentucky Bluegrass Industry in Washington

Description	Irrigated Production	Dryland Production	Seed Processing
Acreage	21,077	39,143	--
Total Production (lbs)	11,297,272	20,550,075	--
Washington Production Processed in Washington (lbs)	5,937,272	16,350,075	22,287,347
Washington Production Exported (lbs)	5,360,000	4,200,000	--
Seed imported for Washington processing (lbs)	--	--	7,354,825
Value of Total Output (Sales) MM ($)	8.25	13.97	30.71
Value of Income MM ($)	3.40	8.17	6.25
Employee Compensation MM ($)	1.18	0.76	3.86
Number of Jobs (including proprietors)	101	170	146

[2]The employment data in the input-output model measure jobs in terms of full time and part time employment.

The Economic Impact Analysis: Ground Rules and Assumptions

To understand the implications of the economic impact analysis it is useful to review the economic assumptions of this study. The impact analysis utilizes a demand driven input-output economic model. In input-output analysis, supply is assumed to always respond to changes in aggregate demand, where economic supply (measured as the value of output of each sector) is a function of exogenous variables representing final demand (e.g. investment demand, government demand, and export demand).

The supply of every good or service is assumed to be produced with constant returns to scale production technology. All primary factors of production are assumed to be characterized by perfectly elastic supply functions and all primary factors are assumed to be perfectly mobile. As a result of these collective assumptions, the supply curve of every good or service produced in the economy is perfectly elastic with marginal cost of output equal to average cost of output. In the language of welfare economics, there is no producer surplus because all supply curves are perfectly elastic. Likewise, since output prices are fixed there is no measure of consumer surplus.

In an input-output analysis, changes in regional well being are measured as changes in the payments to the primary factors of production (gross regional product) or as changes in household income for regional households. (For additional discussion on the regional household income measure, see the Appendix).

The economic impact analysis is known as comparative statics. In the analysis, the economy is assumed to be in economic equilibrium (baseline). Some sort of an economic shock (a change in public policy) is introduced which disturbs the equilibrium and the economy adjusts to a new equilibrium. The impact of the economic shock is measured by comparing the new equilibrium outcome to the original (baseline) equilibrium.

In the analysis of a new economic constraint such as a limit on grass seed field burning, a comparison of the baseline with the new equilibrium will necessarily indicate some loss of jobs and income to the Washington economy. What happens at the national level is another matter and becomes the basis for translating the results of the economic impact analysis into estimates of economic cost. It is possible (although unlikely) that the unemployed (from the point of view of the Washington economy) capital and labor would fail to find re-employment. In this case, the loss in Washington income is identical to the loss in national income and the income loss from the economic impact analysis is equal to social cost. However, it is also possible (although unlikely) that the unemployed labor and capital would find employment at the same return they received in the baseline Washington economy. In this case, the loss in Washington income would be offset by a gain in the rest of country income. The level of total national income would be unaffected and the social cost of the policy would be zero. And, of course, it is possible that the loss in Washington income would be only partially made up by employment of primary factors outside of Washington. Then some of the loss in Washington income would also depress the national income and this reduction in national income would indicate the total economic cost of the policy.

In practical terms, the figures from the economic impact analysis were adjusted in the final cost estimates to reflect the expected re-employment of capital and labor throughout the economy. The adjusted figures represent the total economic cost of the policy. These estimates can be found in the summary and main reports.

The Washington input-output model represents the production and consumption decisions in the economy as a system of simultaneous linear equations. The model represents all goods and service producing sectors in the economy. In the model constructed for this study, 59 separate industries were identified.

The input-output model is a Type II model. This means that the ripple effect captured in the model consists of both an inter-industry effect (indirect) and a household-consumption (induced) effect. In other words, in response to a demand shock (direct effect) the economy is assumed to adjust by changing supply. The equilibrium change in supply across all industries is captured by the direct, indirect, and induced effects. The ripple effect in a Type II model is the sum of the indirect effect and the induced effect. The direct effect is measured by changes in the directly affected industry. In the case of a reduction in grass field burning, the direct effect would be the change in productive inputs, the change in yields, and the change in grower income. The indirect effect would be measured by all other industries change in output and income in response to grass growers changes in production practices. The induced effect is the change in household spending induced by the change in grower income that stems from the reduction in burning. Thus, the total economic impact of a given economic shock as the economy adjusts from the old to a new equilibrium will consist of the sum of the direct, indirect, and induced effects.

Finally, it should be noted that the limit on grass seed field burning does not fit nicely into the conventional demand driven assumptions of the input-output model. (Yet, the input-output model was the only general equilibrium model available, given the study deadline constraint.) There is not a clear connection between the given policy shock and the associated change in a set of exogenous model variables. The burning constraint affects primarily grass seed production and grass seed processing, yet we must capture the economic impact of this policy constraint in a model in which all the exogenous variables are demand variables. To deal with this problem, we constructed a set of "industry adjustment scenarios" that, based on our best judgement, capture the full range of likely grass seed industry adjustments to the limitation on grass seed field burning. These scenarios are then used to structure the economic impact analysis in which supply shocks to the grass growers and processors are simulated as demand shocks in the input-output model. For a more complete discussion of this procedure see Petrovich and Ching (1978) or Lee, Blakeslee, and Butcher (1976).

GRASS SEED SCENARIOS

Three possible scenarios are developed to capture the range of industry adjustment to the grass seed field burning limit. In the **"least costly"** or low impact scenario, growers are able to find alternatives to field burning that allow grass seed production to continue to compete for land labor and capital. In this scenario, seed production costs are increased and yields are slightly reduced (see budget data). Processors are able to make up for the small reduction in Washington grass seed production attributable to the lower yields associated with the field burning limit by increasing imports of seed to process. In the **"most costly"** or high impact scenario, growers are unable to find alternatives to field burning on two-thirds of their grass seed acreage. They must plant less profitable wheat on the grass seed acreage previously burned. In this scenario, irrigated wheat replaces grass seed production on all lost irrigated grass seed acreage, but only 90 percent of the previously burned dryland grass seed acreage is converted to dryland wheat. Ten percent of dryland grass seed acreage is assumed to be too steep to be planted to dryland wheat. Furthermore, Washington grass seed processors are assumed to be unable to find alternative sources of grass seed supply from imported sources which reduces the Washington processing level in response to decreased Bluegrass seed production in Washington. Finally, we have the **"moderate cost"** scenario. This scenario is called the "half-out" scenario in the final report because about half of the grass production is lost. In this scenario, growers switch some of their grass seed acreage to wheat while experiencing a reduction in grass seed yield and an increase in production cost in their remaining non-burn acreage. Grass seed processors are able to replace some of the lost Washington seed production with increased imports, but not all. A more complete description of the assumptions associated with each scenario is presented in the next section. These scenarios were designed to capture the range of potential impacts for analytic purposes rather than to represent the probable range of impacts of implementation of the rule.

Least Costly (Low Impact) Scenario

Growers find a way to produce grass seed that allows the crop to compete for labor and land. Processing plant production levels are unaffected.

Grower Impact

- Per-acre yield slightly decreases.
- Per-acre costs moderately increase.
- Net effect is to reduce Washington Bluegrass grower returns to land, labor, and capital (reduces value added).
- Assumes that grass seed continues to be produced on the impacted acreage using mechanical residue control.

Processor Impact

- In-state processors are able to compensate for reduced production levels by finding additional sources of supply. Therefore, processor economic impact is zero.

Most Costly (High Impact) Scenario

All grass acreage affected by the 2/3 reduction in burn acreage is forced out of production. Processors are directly impacted because alternative grass seed supplies cannot be found to substitute for the decreased output levels attributable to the burn ban.

Grower Impact

- 90 percent of lost dryland grass acreage into wheat rotation.
- 10 percent of lost dryland grass acreage out of production (land too steep to plant to wheat).
- 100 percent of irrigated grass acreage goes into irrigated wheat rotation.
- Wheat assumed to replace grass seed on impacted acres.

Processor Impact

- In-state processors have no additional supply to compensate for banned burn acreage. Assumes that reduced grass seed production affects in-state and out-of-state processors in proportion to their absorption of Washington supply.

Moderate Cost (Half-Out) Scenario

Assumes one of three things happen to acreage impacted by the 2/3 reduction in permitted burn acreage: 1) a portion of the acreage will be switched to a wheat rotation; 2) some dryland acreage will go out of agricultural production; and 3) and some grass acreage will be produced using mechanical residue management techniques which have lower average yields and higher per-acre production cost. Washington processors are assumed to be able to partially offset a portion of the production decrease resulting from reduced planted acres and/or reduced yields on mechanically managed acres by developing alternative sources of supply from outside the state.

Grower Impact

- Produce 50 percent of impacted grass acreage (dryland and irrigated) under mechanical residue management techniques (crewcut vacuum). Relative to burned acreage, results in a small reduction in average yields and higher per-acre production cost.

- Convert 40 percent of the remaining affected dryland acreage to a less profitable wheat rotation. The rest of the dryland acreage, 10 percent, goes out of production (land is too steep to put in an alternative crop).

- Convert the other 50 percent of the remaining affected irrigated grass acreage to irrigated wheat acreage.

Processor Impact

- In-state processors are assumed to compensate for 50 percent of the state level reduction in grass seed supply by finding out-of-state suppliers (Oregon and Idaho).

Table 2 summarizes each of the scenarios to be analyzed.

Results--Direct Effects

Low Cost (Low Impact) Scenario

As a preface to the results discussion, it is useful to review the assumptions that underpin the analysis. The economic impact analysis for each scenario should be viewed as the result of an intermediate run adjustment. That is, growers are assumed to have had time to adjust to the burning limitation and grass seed processors have had time to adjust to grower changes in production. All sectors in the economy adjust to the new equilibrium using the same production recipe. (All production functions for all industries except grass seed growers are assumed unchanged.) What this means is that a given change in industry output will be accompanied by a change in all inputs purchased by that industry in the same proportion. This is consistent with the adjustment process assumed to generate indirect and induced effects in the regional input-output model. Given the fixed proportion assumptions built into the input-output model, the economic results from such a model are usually viewed as the upper limit of changes that would characterize the more flexible real world economy.

In the low cost scenario, grass seed processors are not directly affected. The reduction in grower production is made up by imported grass seed by the processors. Grass seed producers continue to produce grass on the same acreage as before, but receive less yield, less gross revenue, and have higher costs. The main economic impact in this scenario is a reduction in grower income. The direct effect is a reduction in total grower income of $5,400,000 (Table 3). However, grower employee compensation (wage payments) increases slightly under the non-burn technology because it is more labor intensive than the baseline burn technology.

Table 2. Scenarios to be Investigated and Underlying Technical and Behavioral Assumptions for Grass Seed Study

	Scenario		
Economic Agent	Low Cost	Moderate Cost	High Cost
Grower	Per-acre yields slightly decrease under mechanical residue control. Per-acre production costs are higher.	Produce 50 percent of impacted acreage under mechanical residue management (crewcut vacuum). Slightly higher production costs and slightly lower per acre yields. Switch 40 percent of affected dryland acreage to a less profitable wheat rotation. Of affected dryland acreage, 10 percent goes out of production as land is too steep to be farmed in another rotation.	90 percent impacted dryland grass seed acreage goes into a less profitable wheat rotation. 10 percent of impacted dryland grass seed acreage goes out of agricultural production. 100 percent of impacted irrigated grass seed acreage goes into irrigated wheat rotation
Processor	No economic cost. Any decreased in-state production is compensated for by new sources of grass seed supply.	In-state processors are able to find additional sources of grass seed production (either in-state or out-of-state producers) for 50 percent of the lost in-state production.	In-state processors are unable to find any additional supply sources to substitute for the lost in-state production.

Table 3. Direct Employment, Sales, and Income Effects of Proposed Limitation on Grass Seed Field Burning

Direct Policy Impact	Employment	Sales (millions $'s)	Total Labor and Capital Income (millions $'s)	Employee Compensation (millions $'s)
Grower (Includes grass and wheat)				
Low Cost Scenario	+3	-0.41	-5.40	+0.024
Half-Out Scenario	-46	-3.08	-5.49	-0.342
High Cost Scenario	-86	-5.62	-5.58	-0.707
Processor				
Low Cost Scenario	0	0.00	0.00	0.000
Half-Out Scenario	-18	-3.84	-0.78	-0.483
High Cost Scenario	-72	-15.07	-3.07	-1.899

High Cost Scenario

In this scenario, grower acreage of Bluegrass is reduced by two thirds, all lost irrigated acreage and 90 percent of dryland grass seed acreage is shifted into a corresponding irrigated or dryland wheat rotation (10 percent of the land used for dryland grass seed production is idled). Processor output is reduced by 2/3 of the lost in-state production going to in-state processors. Grass seed processors are assumed to reduce input purchases and employment in proportion to the reduction in Washington produced grass seed output.

The direct reduction in processor sales is estimated to be $15,070,000. The associated reduction in processor income is $3,070,000 and the reduction in processor jobs is 72 (Table 3). The direct change in grower income reflects some of the formerly burned land going out of production with the rest of the formerly burned land being converted to a wheat rotation. The direct reduction in grower income is estimated to be $5,580,000. The direct employment loss (the difference between the loss of employment in grass seed production and the gain in employment from increased wheat production) is 86 jobs which translates into $707,000 of forgone employee compensation.

Moderate (Half-Out) Scenario

In this scenario, growers continue to grow Bluegrass seed using mechanical methods of residue removal on 50 percent of their impacted acres and switch the other 50 percent of the impacted acres to a wheat rotation. Grass seed produced on the impacted acres is characterized by higher cost and lower yields. Washington Bluegrass processors are able to find imported seed to replace 50 percent of lost Washington grower Bluegrass output that would have been processed in state.

The direct reduction in processor sales is estimated to be $3,840,000. The associated reduction in processor income is $780,000 and the reduction in processor jobs is 18 (Table 3). The direct reduction in grower income is estimated to be $5,490,000. The direct change in grower employment is 46 jobs as wheat is less labor intensive than grass seed production.

Discussion of Results

Grower direct income impacts are of the same order of magnitude under all scenarios. This comes from the assumption that growers will not idle land affected by the burning limitation, but even in the high cost scenario, grow an alternative crop (wheat). Processors, on the other hand, experience a wide range of direct income impacts across the range of scenarios. The range of processor direct income effect is driven by the assumption of availability of imported grass seed supply. In the low cost scenario, processors are assumed to totally replace the reduction in Washington production with imported supply so their production is unaffected. In the high cost scenario, processors are assumed to be unable to replace any of the lost Washington grass seed production. The assumption about processor capital is different than it is for grower land. If it becomes unprofitable to grow grass seed, the grower is assumed to switch to an alternative crop. If the processor has no grass seed to process, there is no alternative use for that capital.

Results--Total (Direct, Indirect, and Induced) Impacts

It should be noted that all total impacts are economy-wide for the Washington economy. For example, the loss in income under the low cost scenario is estimated to be a loss of $8,030,000 (Table 4). This includes the loss associated with the directly affected industries (growers and grass seed processors) from Table 3 plus the loss in income from all other industries in the Washington economy that stems from the direct impact. In the high cost scenario, the total impact on the Washington economy is estimated to be a loss of $13,990,000 in income and a loss of 316 jobs (Table 4). The moderate cost scenario is characterized by a loss of $9,690,000 in income and 168 jobs.

Table 4. Total Economic Impact (Employment, Sales, and Income) of Proposed Limitation on Grass Seed Field Burning on the Washington Economy

Total Policy Impact	Employment	Sales (millions $'s)	Income (millions $'s)	Employee Compensation (millions $'s)
Low Cost Scenario	-89	-4.46	-8.03	-1.57
Half-Out Scenario	-168	-12.24	-9.69	-2.93
High Cost Scenario	-316	-29.37	-13.99	-5.95

Discussion of Results

The relatively small direct employment effect (Table 3) in the low cost scenario becomes a more significant total economic impact at the state level (Table 4). This result is largely explained by the loss in direct income associated with the low cost scenario. The ripple effect (induced) stemming from the loss in grower income results in loss of household spending, which causes the loss in jobs in the goods and services sectors that serve households. As noted previously, all total economic impacts should be viewed as the result of a very inflexible adjustment process.

Sensitivity Analysis of the Half-Out (Moderate Cost) Scenario

Given the large and relatively constant direct income loss incurred by grass seed growers under each scenario, sensitivity analysis was performed on the most likely moderate cost scenario to examine how sensitive the income loss estimates were to the assumptions governing the reduced burn production technology and policy implementation. The first modification considered was a change to the reduced burn production technology. The reduced burn technology production function was changed to increase both the average yield on planted acreage and the number of years the grass seed stand remains in production, relative to the moderate cost scenario. This new production function was developed by Painter (1996) and is based upon Canode and Law's research (1977). Under the modified production function, grass seed acreage is only burned every other year. Even though average annual yields are higher and production cost is lower than for the baseline moderate cost scenario, the modified average annual yields are 9 percent less than they are under the pre-ban burn technology and average annual production costs remain higher than they are in the absence of the burn limitation policy.

The second modification considered, is consistent with the proposed legislation that allows an impacted grower " . . . to request an exemption for extraordinary circumstances on 5 percent of the acreage in production on May 1, 1996." Discussion with representatives from the Washington State Department of Ecology (Calkins) revealed that it was likely an exemption that would be granted to those growers who could verify that currently grown grass seed acreage would be left idle under the proposed ban, because the acreage was unsuited for any alternative agricultural activity. Thus, any acreage idled under the moderate cost scenario is assumed to remain in grass seed production, provided the idled acreage does not exceed 5 percent limitation on exempt baseline acreage.

Results--Direct Effects

The impact of the two modifications to the half-out (moderate cost) scenario are compared to the original (baseline) moderate cost scenario in Table 5. Employment levels and employee compensation are relatively unaffected by the two modifications at the grower level. However, grower loss in total labor and capital income is 30 percent less under the alternative burn/production technology than the baseline moderate cost. This primarily results from amortizing the establishment year over the longer grass seed stand life which reduces average annual per-acre production cost. The higher yields associated with the alternative burn technology also contributes to lower grower income and sales losses. The direct sales and income losses are also less under the 5 percent exemption scenario, but the loss reduction is much smaller than when adopting the more efficient production technology.

Processor sale and income levels are also less adversely impacted with both modifications to the moderate cost scenario. Both scenario modifications increase grower production which, in turn, increase the level of processor throughput over the baseline moderate cost levels. Similar to growers, processors benefit more from adopting the alternative technology than the 5 percent exemption because the aggregate grass seed production level is greater when the alternative technology is used. As shown in Table 5, processor employment and employee compensation levels are only minimally affected by these changes to the baseline half-out (moderate cost) scenario.

Results--Total (Direct, Indirect, and Induced) Impacts

Similar to the direct effect findings, the reduction in total income is less for the alternative burn technology than for the 5 percent exemption policy. As reported in Table 6, the total reduction in lost labor and capital income is two-thirds as much under the alternative burn technology compared to the baseline moderate, half-out cost scenario. Lost sales are nearly 28 percent less with the alternative technology. The 5 percent exemption also reduces the total economic burden imposed on the Washington State economy, but to a much smaller degree than the adoption of a new rotational burning technology.

Table 5. **Direct Employment, Sales, and Income Effects of Proposed Limitation on Grass Seed Field Burning: Three Moderate Case Scenarios**

Direct Policy Impact	Employment	Sales (millions $'s)	Total Labor and Capital Income (millions $'s)	Employee Compensation (millions $'s)
Grower (Includes grass and wheat)				
Half-Out Scenario Baseline Assumptions	-46	-3.08	-5.49	-0.34
Half-Out Scenario Rotational Burn	-40	-2.58	-3.85	-0.34
Half-Out Scenario 5% Exemption	-42	-2.67	-5.28	-0.32
Processor				
Half-Out Scenario Baseline Assumptions	-18	-3.84	-0.78	-0.48
Half-Out Scenario Rotational Burn	-14	-2.95	-0.60	-0.37
Half-Out Scenario 5% Exemption	-17	-3.59	-0.73	-0.45

Table 6. **Total Economic Impact (Employment, Sales, and Income) of Proposed Limitation on Grass Seed Field Burning on the Washington Economy: Three Alternative "Half-Out" Scenarios**

Total Policy Impact	Employment	Sales (millions $'s)	Total Labor and Capital Income (millions $'s)	Employee Compensation (millions $'s)
Half-Out Scenario Baseline Assumptions	-168	-12.24	-9.69	-2.93
Half-Out Scenario Rotational Burn	-123	-8.83	-6.46	-2.06
Half-Out Scenario 5% Exemption	-153	-11.09	-9.20	-2.81

Policy Implications

The sensitivity analysis revealed that the economic cost of the burn limit can be reduced if it is possible to adopt technologies that require burning of grass seed acreage on an alternate year basis. (The long-run viability of this technology is still untested on farms.) If this technology is viable over the long-run, per-acre average annual production costs are less than they are under the half-out, moderate cost scenario and average annual yield is slightly higher on all acreage in production (the sum of harvested and establishment acreage). While the 5 percent burn exemption helps to mitigate both grower and processor costs, mitigation was limited to about 10 percent of the costs imposed under the baseline moderate cost scenario. Thus, it is inappropriate for either growers and/or processors to anticipate significant financial relief from the 5 percent burn exemption under the half-out, moderate cost scenario.

References

Canode, C. L., and A. G. Law. "Post-Harvest Residue Management in Kentucky Bluegrass Seed Production." College of Agriculture Research Center, Washington State University, Technical Bulletin 850, (1977).

Hamilton, J. R. and Richard L. Gardner. "Value Added and Secondary Benefits in Regional Projection Evaluation: Irrigation Development in the Snake River Basin." *The Analysis of Regional Science* xx(Mar. 1986):1-12.

Huckel/Weinman Associates, Inc. "Small Business Economic Impact Statement for Revision of Chapter WAC 173-430 to Limit Grass Seed Field Burning Emissions." Report submitted to the Washington State Department of Ecology, (1996).

Hughes, David W. and David W. Holland. "Economic Impacts, Values Added, and Benefits in Regional Project Analysis: Comment." *American Journal of Agricultural Economics* 75(August 1993):759-762.

Jensen, R. C. "The concept of Accuracy in Regional Input-Output Models." *International Regional Science Review* 5(1980):139-154.

Lee, Chinkook, Leroy Blakeslee, and Walter Butcher. "Effects of Exogenous Changes in Prices and Final Demand for Wheat and Energy Resources on the Washington Economy: An Input-Output Analysis." College of Agriculture Research Center, Washington State University, Technical Bulletin 85, (1976).

Miller, Ronald E. and Peter D. Blair. "Multipliers in the Input-Output Model." *Input-Output Analysis--Foundations and Extensions*:Prentice-Hall, Inc., 1985.

Miller, Ronald E. and Peter D. Blair. "Organization of Basic Data for Input-Output Models." *Input-Output Analysis--Foundations and Extensions*:Prentice-Hall, Inc., 1985.

Moore, Charles V. and Don Villarejo. "Pesticide Cancellation and Kentucky Windage. *Choices*, 1996 Vol. 11, No. 3, American Agricultural Economics Association, Ames, IA.

Painter, Kate. "Estimates of Acreages of Grass Fields with Burning Permits." Department of Agricultural Economics, Washington State University (1996).

Petkovich, M. D. and C. T. K. Ching. "Modifying a One Region Leontief Input-Output Model to Show Sector Capacity Constraints." *Western Journal of Agricultural Economics* 3, (1978):173-179.

Waters, Edward C., David W. Holland, and Bruce A. Weber. "Interregional Effects of Reduced Timber Harvests: The Impact of the Northern Spotted Owl Listing in Rural and Urban Oregon." *Journal of Agricultural and Resource Economics* 19(1994):141-160.

Young, Robert A. and S. Lee Gray. "Input-Output Models, Economic Surplus, and the Evaluation of State or Regional Water Plans." Water Resources Research, Dept. of Agricultural and Resource Economics, Colorado State University, Fort Collins 21(December 1985):1819-1823.

ADDENDUM TO TECHNICAL REPORT, APPENDIX A

One of the interesting features of the input-output model constructed for this study is its income distribution capability. The model makes the standard fixed proportion assumptions regarding the distribution of factor income to institutions including households. Factor payments made by industries in Washington are tracked to their ultimate destination in Washington households, non-Washington households, governments or firms.[3] Households are assumed to pay direct taxes, save, and consume in fixed proportions according to their position in the size distribution of income.

Households are ranked according to their position in the size distribution of household income. Household income is measured before federal income taxes, but after transfers such as social security payments. Three classes of household income are identified. Low income households (less than \$20,000); medium income households (\$20,000 to \$40,000); and high income households (greater than \$40,000). According to the 1990 Census of Population, roughly, 30 percent of Washington households were in the low income class, 32 percent were in the medium class, and 38 percent were in the highest class.

As a result of the income distribution feature of the input-output model, it is possible to estimate not only how a given economic policy will change payments to the primary factors of production as noted in Tables 3-6, but also how before-tax income of Washington households will change. In addition, we can measure how that change in household income will be distributed between low, medium, and high income households in Washington.

For example, consider the low cost scenario. The total change in household income to Washington households is estimated to be a loss of \$7.24 million. This is the total economic impact of the policy as it it relates to changes in income received by Washington households. The distribution of that income change is estimated to be a loss of \$.21 million to low income households, \$1.16 million to medium income households, and \$5.44 to high income households (Appendix Table 1.) Of the loss in household income, 75 percent accrues to high income households. This is mainly a function of the fact that much of the loss of factor income is in the form of proprietor (sole ownership business) income, and this form of income payment is largely claimed by households in the high income group.

The same interpretation applies to the figures for the other scenarios in Appendix Table 1. Perhaps the major point to emerge from these figures is that regardless of the scenario, most of

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[3]Some of the income paid to the primary factors of production is not received by Washington households. Some of the income is retained by firms for future investment. Some of the income is paid to state and federal governments in the form of factor taxes (social insurance contributions etc.). Some of the factor income is paid to claimants who live outside Washington. And, finally, some of the income is paid to the federal government by firms in the form of corporate income taxes.

the loss in household income in Washington stemming from the limit on the burning of grass seed fields falls upon the high income households in Washington.

Appendix Table 1. Changes in Washington Household Income and the Distribution of Income

Scenario	Change in Total Household Income $MM	Change for Low ($0-19,999) Income Households $MM	Change for Mid. ($20,000-39,999) Income Households $MM	Change for High ($> 40,000) Income Households $MM
Low Cost	-7.24*	-0.21	-1.16	-5.44
Moderate Cost	-8.56	-0.26	-1.91	-6.38
High Cost	-12.05	-0.39	-2.77	-8.89
Moderate Cost Alternative Burn	-5.71	-0.18	-1.28	-4.25
Moderate Cost 5% Exemption	-8.04	-0.25	-1.80	-6.00

*The reader may note the different income estimates for the Low Cost Scenario in Table 4. and Appendix Table 1. In Table 4, the income measure is total factor income. In Appendix Table 1, the income measure is total household income. Some factor income "leaks" out of the household payment stream as it is distributed to households (see footnote 3).

APPENDIX B

Estimates of Farm and Environmental Costs of Increased Restrictions on Grass Seed Field Burning

Technical Report

December 18, 1996

Submitted to:

Washington Department of Ecology
Air Quality Program
P.O. Box 47600
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Revised publication version. The version contains format edits and copy edits to the "Estimates" report dated January 7, 1997. Both versions are available for review. No substantive changes were made from the January 7, 1997 version.

Introduction

Bluegrass production is a risky business, both agronomically and economically. Bluegrass yields are highly sensitive to environmental conditions. In dryland areas yields may vary between 100 and 1,000 pounds per acre due to weather variations alone. Bluegrass can also be difficult to establish. Prices are sensitive to supplies in this relatively small industry, and can fluctuate greatly from year to year. In addition, there are a large number of bluegrass varieties with different characteristics, making it difficult to make generalizations about the industry.

Air quality concerns from open field burning are not new. In the late 1960s, these concerns prompted a large research project conducted by Washington State University beginning in 1968. Research into practical non-burning methods were conducted by Washington State University at six sites over a period of seven years. A summary of the study stated that removal of primary residue by baling reduced yields an average of 32 percent in the second seed crop, 46 percent in the third crop, and 60 percent in older stands compared to open field burning (Canode and Law, 1977). More thorough removal of stubble beyond simply baling primary residue increased yields, but the costs of removing this secondary residue were often greater than could be justified by the increase in yield. Machine burning of stubble and thatch at high temperatures after straw removal appeared to be the best alternative to open burning of residue. Yields from this procedure compared favorably with open field burning. The development of a burning machine has been problematic, however. Another approach examined the practice of open field burning after the second seed crop but not after the first seed crop. Yields for the third year were essentially the same as burning after each crop.

In 1974, the Washington State Legislature amended the Washington Clean Air Act to give the Department of Ecology jurisdiction over emissions from open field burning of the grass seed industry. At that time, the Department of Ecology adopted guidelines to 1) minimize the adverse effects on grass field burning on Washington air quality; 2) provide for implementation of research to find practical alternatives to grass burning, and 3) provide interim regulation of grass burning until practical alternatives were found. Bluegrass industry opposition to the burning ban prevented any further action on the issue of open field burning. Two decades later, public pressure has once again mounted in opposition to open field burning.

The rest of this paper is organized as follows. We first present an analysis of farm level economic impacts of the proposed field burning limitation. Next we analyze the environmental impacts of the proposed limitation. We then present an integrated analysis of farm costs and environmental costs consistent with the analysis of processor and general economic impacts reported in another technical report (Holland and Willis).

Farm-Level Economic Impacts of the Proposed Open Field Burning Limitation

This analysis builds upon a multi-state research project entitled "Bluegrass Seed Production Without Open Field Burning" currently underway at Washington State University, the University of Idaho and Oregon State University on non-burning methods for producing both dryland and irrigated Kentucky bluegrass (STEEP project #PSES 061-K534). Enterprise budgets for producing common and proprietary varieties of Kentucky bluegrass were developed in close coordination with growers for both irrigated and dryland production (Hinman, personal communication). Typical yields were determined using results of three years of on-farm field trials as well as input from growers. The bluegrass price is based on the 1991-1995 average price and the typical differential for proprietary varieties.

Scenarios

Table 1 presents average production costs, yield, revenue, and returns to land and management for various bluegrass production methods for irrigated and dryland areas. These figures are averaged over the life of the stand, including the establishment year. Although bluegrass is typically produced as part of a longer rotation, this study examines the production of bluegrass alone since it is an industry-level rather than a farm-level study. In any case, information on every farm and its proportion of bluegrass to other crops on their farm would have been extremely difficult to obtain. Thus, all cost figures in Table 1 reflect the fact that, during the establishment year, there is no crop nor need for residue removal through burning or non-burning methods.

Yields

Starting with the base line scenario for irrigated production, yields are 670 pounds per acre for each year of production in the burn scenario (scenario one). In the second scenario, yields are assumed to be 670, 574, 670, 574, and 670 pounds per acre in years two through six. In this scenario the stand is burned twice in six years, or one-third of the time, after every second year of seed production. For scenario three, yield is 670 pounds per acre the first year and 574 pounds the second year. Stubble is removed mechanically after the first harvest. In all rotations, both irrigated and dryland, the bluegrass stand is chemically killed in the last year.

In the dryland region, yield is 600 pounds per acre for every year in the burn scenario. In scenario two, the yield alternates between 600 and 480 pounds per year, with the larger yield in the first year and in subsequent years following field burning. For scenario three, the yield is 600 pounds in the first year and 480 in the second year.

Table 1. Average Returns to Land and Management to Bluegrass Production, Including Various Burning Scenarios, and Typical Non-bluegrass Crop Rotations by Area ($/ac/year)

	Years in Rotation	Prod. Costs	Yield	Revenue	Returns to Land and Management
		($/A)	(lbs./A)	($/A)	($/A)
Irrigated Areas					
1. Burn residue	5	325	536	456	131
2. Burn every 2nd year	6	349	526	447	98
a) $15/acre subsidy for residue removal	6	344	526	447	103
b) market for straw	6	336	526	447	111
c) both a) and b)	6	331	526	447	116
3. Mechanical residue removal	3	331	415	353	22
a) $15/acre subsidy for residue removal	3	326	415	353	27
b) market for straw	3	317	415	353	35
c) both a) and b)	3	312	415	353	40
4. Other crop rotations	7	varies	varies	varies	96
Dryland Areas					
1. Burn residue	8	220	525	420	200
2. Burn every 2nd year	6	242	460	368	126
a) $15/acre subsidy for residue removal	6	237	460	368	131
b) market for straw	6	229	460	368	139
c) both a) and b)	6	224	460	368	144
3. Mechanical residue removal	3	247	360	288	41
a) $15/acre subsidy for residue removal	3	233	360	288	46
b) market for straw	3	242	360	288	55
c) both a) and b)	3	228	360	288	60
4. Other crop rotations	4	varies	varies	varies	28

NOTE: Price assumptions are $0.80 per pound for common bluegrass (CBG) and $0.85 per pound for proprietary bluegrass (PBG).

Returns

Per acre returns to land and management for bluegrass production are highest for the burn residue scenario in both irrigated and dryland production (Table 1). In the irrigated areas, returns for bluegrass production with burned residue average 50 percent higher than the "other crop rotations" scenario. In the dryland areas, returns for other crop rotations average just one-eighth of the returns under burned bluegrass. The "other crop rotations" scenarios represent average returns over a typical crop rotation cycle for irrigated and dryland areas. For irrigated production, this represents four years of alfalfa followed by one year each of potatoes, grain corn, and winter wheat. In the dryland regions, a rotation of small grains is used. This regional difference indicates that farmers in the irrigated areas have much better alternatives to bluegrass production than those in the dryland areas.

When fields are not burned following harvest, other methods for removing grass stubble must be used in order to maintain a good crop yield for the following year. Table 1 shows the large drop in expected returns under the mechanical residue removal scenarios in both regions. Mechanical residue removal consists of cutting, baling and stacking the primary residue (straw), which is estimated to be a $40 per acre operation. A crewcut vacuum is used to remove the secondary residue for a cost of $30 per acre based on custom rates for this operation. There is no charge included for disposal of either the primary or secondary residue. Ideally, the grower could recoup some of the expenses from residue removal if there were a local market for the straw. Assumptions a) through c) in Table 1 show how markets or subsidies for this residue would impact returns to land and management. In a), a $15 subsidy covers half the cost of the crewcut vacuum operation. In b), a market for straw is available which is assumed to just cover the $40 cost of harvesting it. In c), both a) and b) occur, so mechanical residue removal costs total $15 per acre. Despite this large decline in income using non-burn methods, dryland farmers would still earn more using these methods than growing alternative crops under the assumptions used in this study. However, non-burn methods may not be feasible on dryland areas that are too steep to bale.

Scenario 2 in Table 1 describes a bluegrass rotation in which burning takes place after every second seed crop. This rotation is based on experimental work by Canode and Law showing bluegrass yields after burning the second crop that were the same as burning after every crop. If farmers burned their fields after every second year of production, they could burn just one-third of their base over a six-year cycle in the following manner: Year 1, establishment; year 2, mechanical residue removal; year 3, burn stubble; year 4, mechanical residue removal; year 5, burn stubble; year 6, take out crop. At first, this may mean burning more than one-third in one year and less than one-third in another year until the rotational cycles were established to burn one-third of the acreage each year. A longer cycle of eight years with burning in three of those years would result in 37.5 percent of the total acreage being burned. Growers would either need to obtain the extra burning percentage through trading, if allowed or to reduce their bluegrass acreage if they were to use an eight-year rotation. An eight-year rotation would increase average net returns by approximately 11 percent under current prices over a six-year rotation.

Returns for burning every second year of production are much higher than mechanical residue removal alone, as the rotation is longer and costs are lower than the non-burning rotations which tend to become uneconomical after just two crops. In the original study, results indicated that burning after the second year of production would reduce yields in the second year by 30 percent, assuming removal of primary residue only (Canode and Law). Here we have assumed removal of both primary and secondary residue with yield reductions in the second year based on these practices. Plot data show yield declines of 15 percent in irrigated areas and 20 percent in dryland areas following the first year of mechanical residue removal of both primary and secondary residue. Under these assumptions, returns would decline by 22 percent in the irrigated areas for the burn-every-other-year scenario compared to the pre-rule burn residue scenario, and 28 percent in the dryland areas.

If there is a market for the bluegrass straw that would make baling primary residue a break-even proposition, returns would decline by 13 percent in the irrigated areas and 21 percent in the dryland areas. A $15 per acre subsidy on the secondary residue removal costs combined with a straw market would result in 10 percent and 18 percent reductions in net returns relative to returns under open field burning. These results are contingent upon the assumption that stands would remain viable with every-other-year burning.

Several proposed projects for using bluegrass straw are under study. These include biomass recycling, a paper manufacturing plant, and a plant for producing wood from straw. Estimated costs for removing and storing residue for the biomass recycling project would be about the same as item c) in Table 1, or $15 per acre. Costs for residue removal under the assumption that there is a bluegrass straw market for the paper or pulpwood plants would be similar to costs in item b, or $30 per acre. While these plants may offer more than a break-even price for the straw, transportation costs to the plant might use up any profit. The impact of these assumptions on net returns can be seen in Table 1.

Environmental Impacts of a Change in Bluegrass Acreage

The environmental impact of a change in bluegrass acreage will be highly dependent upon the specific area affected and what is grown in its place. Environmental damage such as water quality degradation is dependent upon factors such as field steepness, soil type, precipitation, location of waterways, and specific farming practices. Bluegrass is an excellent crop for preventing soil and wind erosion and the environmental damage that accompanies it. Dollar estimates of damage are based upon erosion estimates for bluegrass and for the typical alternative rotation in the dryland and irrigated areas.

The erosion impact of replacing bluegrass production with alternative crop rotations was estimated to be an additional 1.5 tons/acre of sheet and rill erosion, 0.5 ton of concentrated flow erosion, and 1 ton/acre of wind erosion based on a study by the Spokane County Natural Resource Conservation Service entitled Water Quality Benefits of Bluegrass in Spokane County. No erosion is predicted to occur under bluegrass production. While it is difficult to place an accurate value on damage to air, water, and soil quality, it is important to acknowledge these impacts and attempt to estimate their value. Most studies measuring the value of erosion control have used a value between $1 and $5 per ton of soil lost (Ribaudo, 1989; Dailey, 1994; Forster and Abrahim, 1985). Ribaudo's estimates of total downstream impacts are widely used in valuing erosion damage; his estimate for the Pacific region including Washington State is $3.05 per ton of erosion (1995 dollars). On-site erosion damage is estimated as an additional $1.50 per acre of bluegrass removed from production (Painter et al., 1995) Wind erosion damage has not been quantified in this format. For this study, an estimate of $5/ton is used to account for all water erosion-related damage for a total erosion impact of $15/acre. While this estimate is based on Spokane County erosion estimates, most dryland bluegrass is produced in this area. A more accurate value might be obtained with a detailed study of the bluegrass terrain in Washington State, but this was not possible within the time frame of this study.

Environmental impacts of reduced bluegrass acreage will be quite different for dryland and irrigated bluegrass production. In the irrigated bluegrass areas, wind erosion is the major environmental concern. The Tri-Cities and Spokane both fail to meet federal air quality standards due to PM-10 emissions from time to time. The cover that bluegrass production provides over winter provides excellent protection from wind erosion. Given the wide range of wind erosion estimates and the nature of wind events, it is difficult to predict an average figure for bluegrass production compared to the typical alternative rotation. Wind erosion values may range from 4 to 21 tons per acre for a typical rotation in the Columbia Basin, depending on the location, soil type, farming practices, and wind characteristics (Crowse, personal communication). The correct value to use for this study depends upon the crops chosen to replace bluegrass. If alfalfa is grown instead of bluegrass, erosion impacts will be very small. If a typical corn, wheat, and potatoes rotation is substituted for bluegrass production, erosion impacts will be much greater. However, wind erosion savings of at least 3 tons per acre of bluegrass will be observed across most of the irrigated areas, with much larger savings in some regions like the Horse Heaven Hills. For this reason, a $15 per acre value (3 tons at $5/ton damage) for bluegrass production compared to the typical alternative rotation was used for irrigated land.

Estimations of Economic and Environmental Impacts of Rule Change by Region and Scenario

Table 2 presents changes in regional bluegrass acreage for four scenarios using current prices. These results are slightly simplified in order to fit the needs of the input-output model of the bluegrass processing industry in Washington State. The first scenario, the pre-rule situation, assumes burning 100 percent of bluegrass residue on 60,220 acres in Washington State. Irrigated acres represent 35 percent or 21,077 acres while the remaining 39,143 acres are under dryland production.

The exact acreage of bluegrass currently under cultivation is unknown. There are about 40,000 acres permitted for burning. Washington Agricultural Statistics also reports about 40,000 acres of bluegrass. However, these official figures appear to be underestimates. By using the higher of the acreage from 1996 burn permits or the amount of acreage reported in bluegrass acreage as part of conservation plans we could document about 54,000 acres. However, information from seed processors indicates that there may be even higher acreage. We based a final estimate of acreage on the documented 54,000 acres adjusted upwards based on the information from processors. We have used 60,220 acres of planted bluegrass in this study. Although this is more acreage than we can document, it is more consistent with the information from seed processors than lower estimates would be.

Table 2. **Returns to Land and Management for Irrigated and Dryland Bluegrass Production for Fixed Price Scenarios: High, Medium, and Low Impact by Extent of Grass Acreage Retained (Used for Input-Output Model of the Bluegrass Processing Industry)**

	Returns to Land & Management			Change from Pre-rule	Environ. Impact	Net Change
	($/ac)	(%)	($1000)	($1000)	($1000)	($1000)
Pre-rule:						
Irrigated						
BG burned	131	100	2754	0	0	0
Dryland						
BG burned	200	100	7817	0	0	0
Total			10571	**0**	0	**0**
High Impact:						
Irrigated						
BG burned	131	33	909			
BG nonburn	22	0	0			
BG to wheat	87	67	1227			
BG to idle		0				
Subtotal			2136	-618	-213	-831
Dryland						
BG burned	200	33	2580			
BG nonburn	41	0	0			
BG to wheat	22	60	523			
BG to idle		7	0			
Subtotal			3102	-4715	-393	-5107
Total			**5238**	-5333	-605	**-5938**
Medium Impact:						
Irrigated						
BG burned	131	33	909			
BG nonburn	22	33	152			
BG to wheat	87	33	604			
BG to idle		0	0			
Subtotal			1665	-1089	-105	-1194
Dryland						
BG burned	200	33	2580			
BG nonburn	41	33	533			
BG to wheat	22	30	261			
BG to idle		3	0			
Subtotal			3374	-4443	-195	-4638
Total			**5039**	-5532	-300	**-5832**
Low Impact:						
Irrigated						
BG burned	131	33	909			
BG nonburn	22	67	308			
BG to wheat	87	00	0			
BG to idle		00	0			
Subtotal			1217	-1537	0	-1537
Dryland						
BG burned	200	33	2580			
BG nonburn	41	67	1083			
BG to wheat	22	0	0			
BG to idle		0	0			
Subtotal			3662	-4155	0	-4155
Total			**4879**	-5692	0	**-5692**

Price assumptions are $0.80 per pound for common bluegrass (CBG), $0.85 per pound for proprietary bluegrass (PBG), and $4.00 per bushel for wheat.

Total income at current (five-year average) prices of $.80 per pound for common bluegrass and $0.85 per pound for proprietary varieties is $10.5 million. A simplifying assumption is made that proprietary bluegrass is grown by irrigated producers while dryland producers raise common bluegrass. The next scenario is the high impact situation in which all acres affected by the burning ban on two-thirds of the production base are planted to wheat. In the dryland areas, 10 percent of the two-thirds affected acreage, or approximately 7 percent, is left idle because it is unsuitable for wheat production. The economic impact of switching the affected acreage to wheat is a drop in farm income of $5.3 million, plus another $600,000 in lost environmental benefits.

In the medium impact (half-out) scenario, farmers in both irrigated and dryland areas are assumed to plant half of the affected acreage (33 percent) to wheat, leaving the remaining acreage in bluegrass production using non-burning methods. In the dryland areas, one-tenth of the land or 0.03 percent is assumed to be left idle. This scenario reduces farm income by $5.5 million and incurs an additional $300,000 in environmental costs.

The last scenario is a **low impact scenario** in terms of total bluegrass acreage in that farmers are assumed to continue to grow bluegrass but use non-burning methods on the affected acreage. This scenario has the largest impact on farm income of $5.8 million but has no additional costs in terms of environmental damages. It is surprising that the impact of the three scenarios under the new rule actually have fairly close values in terms of total change in farm income and environmental benefits. The per acre cost of the rule is nearly $100 per acre of bluegrass originally in production under all three scenarios. These choices are obviously not very satisfactory for bluegrass producers.

Bluegrass is a relatively small industry with the bulk of its production in the Inland Pacific Northwest. Prices tend to be quite volatile in response to supply and demand changes. The proposed burning ban on two-thirds of bluegrass acreage in this state could have a large impact on price, depending on how much acreage is put into production outside the state and whether similar burning regulations are imposed in other states as well.

Price Impact Scenario

Table 3 shows the impact of two levels of price changes on per acre and region-wide returns. The pre-rule scenario is identical to that in Table 2. In the **high impact flexible rotation scenario**, it is assumed that the price does not increase in response to the rule as production moves to areas outside Washington State. In this scenario, farmers use alternative crop rotations on the affected acreage, except 10 percent of the acreage impacted by the ban in the dryland area which is left idle. The difference between this scenario and the high impact scenario in the previous table is that the farmer is assumed to use an alternative crop rotation rather than replacing bluegrass with wheat. This is slightly more realistic but it was too complicated to use in the input-output model of the processing industry. Under these assumptions, economic impacts are slightly smaller

Table 3. Returns to Land and Management for Irrigated and Dryland Bluegrass Production Based on Economic, Geographic, and Political Factors, Prices Allowed to Vary

	Returns to Land & Management			Change from Pre-rule	Environ. Impact	Net Change
	($/ac)	(%)	($1000)	($1000)	($1000)	($1000)
Pre-rule:						
Irrigated						
BG burned	131	100	2754	0	0	0
Dryland						
BG burned	200	100	7817	0	0	0
Total			10572	0	0	0
High Impact Flex Rotation:						
Irrigated						
BG burned	131	33	909			
BG nonburn	22	0				
BG to alt. rotation	96	67	1361			
BG to idle		0				
Subtotal			2270	-484	-213	-697
Dryland						
BG burned	200	33	2580			
BG nonburn	41	0	0			
BG to alt. rotation	28	60	662			
BG to idle		7	0			
Subtotal			3242	-4575	-393	-4969
Total			**5512**	-5059	-606	**-5666**
Medium Impact Flex Rotation:*						
Irrigated						
BG burned	153	33	1067			
BG nonburn	39	0	0			
BG to alt. crop rotation	96	67	1361			
BG to idle		0	0			
Subtotal			2428	-326	-212	-538
Dryland						
BG burned	221	33	2851			
BG nonburn	56	34	730			
BG to alt. crop rotation	28	27	296			
BG to idle		07	0			
Subtotal			3877	-3940	-198	-4139
Total			**6305**	-4266	-410	**-4677**
Low Impact; High Price:						
Irrigated						
BG burned	199	33	1384			
BG nonburn	75	50	787			
BG to alt. crop rotation	96	17	345			
BG to idle		0	0			
Subtotal			2516	-238	-54	-292
Dryland						
BG burned	263	33	3393			
BG nonburn	84	53	1752			
BG to alt. crop rotation	28	7	77			
BG to idle		7	0			
Subtotal			5223	-2594	-82	-2675
Total			**7739**	-2832	-136	**-2968**

NOTE: Price assumptions are $0.80 per pound for common bluegrass (CBG) and $0.85 per pound for proprietary bluegrass (PBG) under the Pre-rule and High Impact scenarios, $0.84/lb for CBG and $0.89/lb for PBG (a 5 percent increase) under the Medium Impact scenario, and $0.92/lb for CBG and $0.98/lb for PBG (a 15 percent increase) under the Low Impact scenario. Grain prices are assumed to be $4 per bushel for wheat and $88 per ton for barley.

*Signifies "Most Realistic Estimate"

while environmental impacts remain the same as in the previous table for a total impact of $5.7 million or $94 per acre of bluegrass currently in production.

The medium impact flexible price scenario in this table represents a "best-estimate" case given the current state of technology for non-burn methods. In this scenario, prices are assumed to increase by 5 percent in response to the regulation. Although there may well be an increase in out-of-state bluegrass acreage, it is assumed these areas will not quite make up the lost Washington acreage. In addition, out-of-state growers may also face some regulations or increased costs in the near future, so this small increase in price was justified. Of course, the actual price response is impossible to predict and will have a very large impact on farmer response to this regulation.

Under this best estimate or medium impact scenario, the two-thirds acreage affected by the ban is planted to alternative crop rotations in the irrigated areas. Per acre returns under non-burn production are not competitive with alternative crop rotations at $39 per acre compared to $96 per acre for alternatives to bluegrass. In the dryland areas, the per acre returns for non-burn methods was higher than the returns under alternative crop rotations at $56 compared to $28. Because of difficulties associated with non-burn methods on steep hillsides common to the dryland bluegrass producing region, it was assumed that half of the affected acreage (33 percent) would remain in bluegrass with non-burn methods, 10 percent of the affected acreage (7 percent of total) would be left idle, and the remaining 27 percent would be placed in alternative crop rotations. The economic impact of this scenario is $4.3 million, with an additional $410,000 in environmental impacts for a total impact of $4.7 million or $78 per acre of bluegrass currently in production.

The final scenario predicts impacts with a larger price increase of 15 percent, which may well be the case if other states impose burning restrictions on bluegrass production as well. With higher returns for bluegrass production, it is assumed that approximately half of the total pre-rule bluegrass acreage would go to non-burning techniques in both the irrigated and dryland areas. Returns are still somewhat higher for alternative crop rotations in the irrigated areas, so the remaining 17 percent of original bluegrass acreage in that region is assumed to convert to alternative crop rotations. In the dryland areas, 10 percent of the affected acreage would be idled and the remaining 10 percent would go to alternative crop rotations due to problems with non-burning techniques on steep ground. The economic impact of this higher bluegrass price scenario is a drop in farm income of $2.8 million and another $136,000 in environmental costs for a total impact of just under $3 million or approximately $50 per acre of bluegrass originally in production.

Rotational Burning Scenarios

A final set of scenarios in which fields are burned following every second year of production as outlined earlier is presented in Table 4. Experimental results showed that yields following a burn after the second year were virtually identical to yields in fields that are burned every year (Canode and Law). If the expense of establishing a bluegrass field can be amortized over a longer rotation, production costs will be dramatically reduced. In addition, if non-burning residue

Table 4. Returns to Land and Management for Irrigated and Dryland Bluegrass Production with Burning Fields Every Second Year of Production for a Total of 33 percent of Irrigated Acreage and 37.5 percent of Dryland Acreage

	Returns to Land & Management			Env. Impact	Net Change
	($/ac)	(%)	($1000)	($1000)	($1000)
Pre-rule:					
Irrigated					
BG burned	131	100	2754	0	0
Dryland					
BG burned	200	100	7817	0	0
Total			10572	0	0
Rotational Burning:					
Irrigated					
BG burn every 2nd year	98	100	2067	0	-687
a) $15/acre subsidy on removal costs	103	100	2172	0	-582
b) market for straw	111	100	2348	0	-406
c) both a) and b)	117	100	2454	0	-301
Dryland					
BG burn every 2nd year	141	100	5507	0	-2309
a) $15/acre subsidy on removal costs	146	100	5728	0	-2089
b) market for straw	156	100	6095	0	-1722
c) both a) and b)	161	100	6315	0	-1502
Total Acreage					
BG burn every 2nd year					**-2997**
a) $15/acre subsidy on removal costs					**-2671**
b) market for straw					**-2128**
c) both a) and b)					**-1803**

Price assumptions are $0.80 per pound for common bluegrass (CBG) and $0.85 per pound for proprietary bluegrass (PBG).

removal techniques, currently estimated to cost $70 per acre, are required only every other year, costs will decline. Various scenarios are presented assuming a $15 per acre subsidy toward residue removal costs (a), the existence of a straw market that completely covers the costs of baling and stacking the primary residue (b), and both scenarios combined (c). There are no environmental costs to the rotational burning scenarios as all bluegrass is assumed to remain in production. Prices remain at the current level for the same reason. In reality, there may be some acreage in the dryland areas that are too steep to use these techniques, but that is not considered here. The net economic impacts for rotational burning across both regions range from $3 million without any subsidies or markets for straw to $1.8 million with a $15 per acre subsidy for straw removal and a market for straw. While these scenarios may only be realistic for a certain percentage of the original bluegrass acreage in production, it is obvious from the per acre returns in the second column that rotational burning is much more likely to be competitive with alternatives to bluegrass production than non-burning methods, and would decrease the environmental impacts of a loss in bluegrass acreage.

Impact of 5 Percent Exemption on Dryland Acreage

Table 5 presents the impacts of a proposed 5 percent exemption on the two-thirds burning ban on dryland acreage. Assuming there are extraordinary circumstances such as field terrain that is too steep for non-burning residue removal methods, farmers may be allowed to burn up to 38 percent rather than 33 percent of their acreage. This exemption must be certified by an agronomic professional. For the fixed price scenarios in Table 2, the region-wide economic and environmental impacts of this exemption if it is used by all dryland producers would be an increase in total returns of $390,000 plus $29,000 additional environmental benefits for a total of $419,000 (Table 5). In Table 3, prices were allowed to vary across the high, medium, and low impact scenarios. The high impact scenario uses the same prices as Table 2, resulting in the same total region-wide impact. Bluegrass prices are assumed to rise 5 percent for the medium impact flex price scenario and 15 percent for the low impact high price scenario, which increases total returns to $432,000 and $543,000, respectively, for the two scenarios. Total environmental impacts are the same for all scenarios at $29,000. The total impact for these two scenarios are $461,000 and $543,000. Thus, the 5 percent exemption would have a significant positive impact on net returns as well as the environment if widely used across the dryland areas.

Table 5. Economic and Environmental Impacts of a 5 Percent Exemption on Dryland Acreage on High, Medium, and Low Impact Scenarios

Scenario	Change in Total Returns ($1000/yr)	Change in Env. Impacts ($1000/yr)	Total Impact ($1000/yr)
Fixed Price Scenarios (Table 2)			
High, Medium & Low Impacts	390	29	419
Varying Price Scenarios (Table 3)			
High Impact, Flex Rotation	390	29	419
Medium Impact, Flex Price	432	29	461
Low Impact, High Price	543	29	543

Impact of Proposed Trading of Burning Permits

Tradeable permits are used in air pollution control to decrease the economic burden on polluters. Some industrial plants may prefer to buy a permit than to invest in new technologies such as scrubbers. Other plants may prefer to invest in non-polluting technology and sell some of their permits to pollute. Within one airshed, this type of trading should result in the desired level of air pollution control while allowing individual companies to choose the best strategy for their particular situation.

This concept could be used several ways under the proposed regulation for reducing burned bluegrass acreage to two-thirds of current production. If farmers were allowed to trade permits within one airshed, farmers wishing to continue burning bluegrass at higher levels than permitted under the proposed regulation could buy permits from farmers who decided to quit growing bluegrass, and both parties should be better off.

The reduction in costs from trading were not explicitly estimated due to lack of appropriate data. The benefits of trading are that, once the overall desired limit on burning is set, farmers are able to increase efficiency--"fine-tuning" their farming by using burned bluegrass on the fields most productive under burning. Since we modeled farms in only two broad classes, irrigated and dryland, we were not able to capture the efficiencies that result from shifting burning from one field to another with different productivity and farming cost characteristics. In principle, the trading provision will not change the overall level of burning. However, in practice it is possible that some fields will be burnt that would otherwise not be burned. For instance, if a farmer had most of his bluegrass fields in a rotation (establishment, "take-out" year) where he did not need to burn, he might sell his permit and thereby increase the total burn.

It is also important to note that the impact of the trading provision will depend, among other things, on the scope of area for the rule. If permits were tradable across all of eastern Washington, it is likely that irrigated farmers would sell permits to dryland farmers, especially those in the Spokane area. Such a version of the rule would reduce the benefits of the rule, perhaps substantially. It is therefore assumed here that trading will be within local jurisdictions only. Another approach might be to encourage farmers in an area with air pollution problems and large centers of population to sell their permits to farmers in areas without these characteristics. If all costs of production had to be paid, including externalities such as health impacts on the surrounding population, bluegrass production would naturally move to areas with lower total costs of production. However, the high concentration of producers in Spokane County would undoubtedly be adversely affected and thus this solution would be politically unpopular. Also, as population increases over the years, the problem may simply repeat itself elsewhere.

What is needed for this bluegrass burning situation is a silver bullet that would allow economical production of bluegrass with non-burning methods. The environmental benefits from production of this perennial could then be maintained without the air pollution problem. In the absence of a solution, measures such as allowing burning every second year of production, provision or subsidization of residue removal equipment, and assistance with development of markets for straw would help reduce the economic burden on growers.

References

Canode, C.L. and A.G. Law. 1977. Post-harvest residue management in Kentucky bluegrass seed production. Wash. State Univ. College Agr. Research Center Bulletin 850.

Crowse, Harold, District Conservationist, USDA-NRCS, Grant County, Washington, November 1996.

Dailey, Gary. 1994. "Integrating Nonpoint Source Pollution Costs Into a Comparative Advantage Analysis of White Wheat Production in Idaho's Tom Bealle Watershed." M.S. Thesis, Dept. of Agr. Econ., Univ. of Idaho.

Forster, D.L. and Girmai Abrahim. 1985. "Sediment Deposits in Drainage Ditches: A Cropland Externality." J. of Soil and Water Conservation 40:1(141-143).

Painter, Kathleen, Douglas Young, David Granatstein, and David Mulla. "Combining Alternative and Conventional Systems for Economic and Environmental Gains." *Amer. J. of Alternative Ag.*, 10(2):88-96, 1995.

Ribaudo, M.O. Water Quality Benefits from the Conservation Reserve Program. Agr. Econ. Rpt. No. 606, U.S. Dept. of Agr., Econ. Res. Serv., 1989.

Appendix C

Estimates of Benefits from Reductions in Grass Seed Field Burning

Technical Report

by

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INTRODUCTION

On March 29, 1996, the Department of Ecology issued an emergency ruling that called for a one-third reduction in the number of acres of field and turf grasses that could be burned in Washington in 1996. A permanent rule requiring an additional one-third reduction in 1997 is currently being considered. The proposed rule would modify WAC 173-430, to require "burning of field and turf grasses for seed in 1997 and thereafter (until approved alternatives become available) be limited to no more than one-third of the number of acres in grass seed production on May 1, 1996." State law requires that a benefit-cost analysis examine the economic impact of the permanent rule be completed for such a proposed rule. This report presents the analysis measuring the economic benefits that would be gained under the proposed rule.

The largest potential benefit of the proposed rule is improved air quality from reduced smoke emissions. Epidemiological evidence has established a clear link between small air-born particles and health, particularly for an at-risk population comprising people with existing cardio-pulmonary conditions such as asthma, emphysema, chronic bronchitis or heart disease.[1] Additional benefits from the proposed rule include the benefits of traffic accident reductions, enhanced recreational opportunities, reduced dirt and nuisance effects from smoke particles, and the aesthetic effects of improved visibility.

The primary component of this section of the report presents the results of a contingent valuation survey that was conducted between July and September of 1996. The following discussion will describe the analysis of the survey data that was used to calculate the potential benefits. The population surveyed comprised the residents of Eastern Washington in counties where bluegrass is grown and the residents of two counties in Idaho that are also affected by smoke from bluegrass field burning.

A secondary component of this benefits analysis considers evidence from epidemiology studies and from studies on the economics of health improvements. A final section reports information on the incidence of respiratory and cardiac problems gathered from the contingent valuation survey which can be used to provide some additional rough estimates of the costs that exposure to smoke burning has on area residents.

BENEFIT ESTIMATES FROM CONTINGENT VALUATION SURVEY

Characteristics and Disposition of Survey Sample

A survey instrument was developed by researchers at the Department of Agricultural Economics at Washington State University to measure the household benefits of reducing smoke from grass

[1] There is also some speculation that the higher rate of asthma found in Spokane compared to other regions may be due to the higher levels of particulate pollution in the Spokane area. Since this possibility is still speculative it was not counted in the study.

burning. The survey is described below. It was designed to elicit information on attitudes and values toward smoke from grass field burning, data on health status, demographic information, and other information, described below, needed to estimate economic value. The Social Survey Research Unit at the University of Idaho administered the survey.

The sampling frame used for this study included all listed telephone directory numbers in the study area. By using listed directory numbers the addresses of households are also obtained. This permitted us to send an advance letter to the household notifying them about the study. The sample of telephone numbers for this study was obtained from Survey Sampling, Inc. of Westport, Connecticut, a sampling firm that maintains current lists of telephone directories for the nation. The initial sample contained 3,000 households. Households were randomly selected from telephone directory data banks maintained by Survey Sampling. The goal of the study was to complete 1,500 interviews comprising two subsamples: (1) 750 completed interviews in Spokane County, and (2) 750 interviews covering other affected areas in Eastern Washington and Kootenai and Bonner Counties in Northern Idaho.

A pretest of the questionnaire was conducted between July 18, 1996 and July 24, 1996. A total of 76 pretest interviews were conducted. Interviews using the final form of the questionnaire began on July 25, 1996. A total of 1,561 interviews were completed. Interviews were completed by September 9, 1996. Table 1 presents the percentage of permitted bluegrass acres in each county along with projected household population counts for each county in the sample.[2]

The response ratio (completes / completes + refusals + did not reach) for the survey is 71 percent. The overall cooperation ratio (completes / completes + refusals) is 77 percent. The dispositions of the sample by region is presented in Table 2.

Development of Contingent Valuation Questionnaire

The contingent valuation method (CVM) is a survey based method for eliciting economic values. It works by simulating a market for an environmental amenity or other public good. Respondents are asked to treat the environmental good like a commodity that they might have to pay for--either in a real market or through taxes or fees for government services. Respondents are asked to place a value on a change in the amount or in the quality of a commodity that is expected to result from an environmental policy. In this way, CVM provides economic information about the value of environmental goods or services that do not have any monetary values associated with their use in consumption or production. In the case of a public good like clean air, a voting referendum model is used for further realism. Respondents are asked whether they would approve, and pay for, a program to obtain the desired public good (such as cleaner

[2]Permitted bluegrass acres is an undercount of actual acres in production due to under-reporting. See technical appendix on farm costs for updating of acreage.

Table 1. Number of Household in Sample with Number of Permitted Grass Acres by County

County	Percentage of Permitted* Grass Acres	Number of Households (Sample Frame)	Number of Households (Population)	Percentage of Households
Lincoln	3	3,845	3,958	1.1
Grant	1	14,682	22,963	6.6
Adams	6	3,636	5,045	1.5
Whitman	11	9,933	13,987	4.0
Benton	4	23,440	50,276	14.5
Franklin	2	7,875	13,707	4.0
Walla Walla	3	12,645	19,131	5.5
Columbia	1	1,192	1,689	0.5
Garfield	4	931	907	0.3
Asotin	1	5,345	8,059	2.3
Spokane	64	158,373	158,373	45.7
Total Washington	100	315,088	298,096	86.0
Kootenai	NA	21,819	35,437	10.2
Bonner	NA	9,627	13,001	3.8
Total Northern Idaho	NA	31,446	48,438	14.0
Grand Total		199,360	346,534	100.0

* Permitted acres are about 40,000. We estimate actual planted acres at about 60,000.

air) In this case the environmental improvement or "public good" is a reduction of grass seed field smoke. The method is called Contingent Valuation because the value elicited from the respondent depends or is contingent upon the hypothetical scenario described in the survey instrument.

There are three basic parts to the design of a Contingent Valuation Method (CVM) survey (Mitchell and Carson, 1989):

1. A detailed description of the good(s) being valued and the hypothetical circumstances under which it is made available to the respondent.

2. Questions which elicit the respondent's willingness-to-pay for a change in provision or willingness-to-accept to forgo a change for the good being valued.

3. Questions concerning the demographics and characteristics of the respondents including the extent to which the good in question relates to their household (in this case we asked ,questions concerning farm operations, attitudes toward air pollution, and health questions to determine if the household was in the at-risk group.

Table 2. Disposition of Sample by Region

Dispositions	Eastern WA	Spokane	Idaho
Completed interviews	596	746	219
Refusals	133	252	57
Ineligibles:			
Duplicate Households	3	5	3
Deceased	11	17	2
Business/Govt tel no.	9	18	9
Language problem	54	51	14
Rings Wrong HH/no listing	156	220	55
Illness	25	43	4
Moved out of area	29	51	24
TOTAL INELIGIBLE	287	405	111
Did not reach	71	96	22
TOTAL	1,090	1,500	410
RESPONSE RATE (completes/completes+refusals+did not reach)	74.5%	68.2%	73.5%
COOPERATION RATE (completes/completes+refusals)	81.8%	74.8%	79.4%

More specifically, the questionnaire (available in a separate technical appendix and available by request) contained:

- a section for identifying primary farm operators and asking questions about farm operations and use of field burning as an agricultural practice;
- a section with questions about respondents' perceptions of general air quality and environmental policy;
- a section with questions about the health status of household members and whether any members suffer any major or minor symptoms due to smoke from field burning; the section contained follow-up questions for respondents whose household contained anyone with a chronic respiratory or cardiac condition;
- a section describing the proposed rule to reduce smoke from the burning of bluegrass fields; follow-up questions were asked about perceived benefits or concerns about the rule;

- a section describing the proposed rule, asking whether or not respondents favor the rule (using a referendum format) and asking the value questions; two formats--an opened-end format for one quarter of the sample and a discrete-choice with follow-up format for the rest of the sample) were asked;[3]
- a section with demographic questions (age, income, etc.).

Calculation of the Benefits

A sequence of questions were used to establish the background and then elicit the value for measuring the household benefits due to the proposed rule. First, respondents were given a referendum asking whether they favor or oppose the proposed rule to reduce the number of acres burned by Washington bluegrass producers by two-thirds by 1997. All respondents, including those in Northern Idaho, were told that the rule only affects smoke from bluegrass fields in Washington. Responses to the referendum question are given in Table 3.

Table 3. Results of Revised Vote Count on the Referendum to Reduce Smoke*

Response	Spokane Co.	Eastern WA	No Idaho	Row Total
Favor Program	374 (50.1)	232 (38.9)	110 (50.2)	716 (45.9)
Against Program	302 (40.5)	300 (50.3)	80 (36.5)	682 (43.7)
Would Not Vote	14 (1.9)	7 (1.2)	4 (1.8)	25 (1.6)
Depends on Cost	2 (0.3)	0 (0.0)	0 (0.0)	2 (0.1)
Not sure/No Opinion	48 (6.4)	45 (7.6)	21 (9.59)	114 (7.3)
No Answer	6 (0.8)	12 (2.0)	4 (1.8)	22 (1.4)
Column Total	746 (47.8)	596 (38.2)	219 (14.0)	1561 (100.0)

* Numbers in parenthesis are column percents except Column Total which are row percents.

[3] An opened-ended question directly asks the respondent how much they would pay to receive the benefits of the rule. A discrete choice question asks the respondent if they would pay a set amount (e.g. $25) to get the rule. With a follow-up questions, those that agreed to make the level of payment are asked the maximum amount they would pay, while thus that would not pay the set amount are asked what amount, if any, they would pay.

It is important to note that this survey was not designed as a voter survey. These survey results do not predict how a popular vote on the proposed rule would actually turn out, although they do give some indication of popular sentiment. Voter surveys include questions designed to predict who would actually vote and have other differences from the survey we conducted. Our purpose was to elicit how much the rule was worth to people, not whether it would be approved in a general election referendum.

There were two adjustments made in the voting data. First, respondents who indicated that a program to reduce smoke produced no benefits for the own household were asked if they would vote for the program if it helped other households besides their own. A total of 12 respondents favored the program if it helped others. Second, respondents who indicated that they would not vote for the program either because (1) they did not want to vote, (2) it would depend on costs, (3) they were not sure or had no opinion, or (4) they would not answer, were asked if they would pay anything to get the benefits of the program. Sixty-six of the respondents who voted in these categories indicated they would pay something for the program. The responses of the respondents were recoded to indicate that they favor the program since they indicated they would pay something for it.

Using the revised vote count, the rule is favored by a majority in Spokane County (50 percent in favor with 40 percent against) and Northern Idaho (50 percent in favor with 37 percent against). In Eastern Washington, a majority of respondents oppose the rule (39 percent in favor with 50 percent against).

In order to determine how the vote reflects the combined preferences of Washington residents and also of the entire region represented in the sample, responses from Table 3 were weighted to obtain a fair representation. Table 4 presents the weighted results of vote of just Washington residents. Here, the vote count of Eastern Washington residents is weighted upward by a factor of 1.25 in order to balance the number of households between each region so they can be compared. No further adjustment is needed since both Spokane County and the other counties comprising the Eastern Washington portion of the sample contain roughly the same number of households.

For the Washington state region, slightly less than 45 percent of the households voted in favor of the program while slightly more than 45 percent voted against the program. In view of these results, residents of Washington are evenly split on their support for the rule.

The voting responses were also weighted to determine the outcome for the entire study region. Votes were adjusted in each of the three subsamples in order to give each households the appropriate weight based on the number of households in each of the three regions. The results of this region vote can be found in Table 5. Overall, the program is favored by a slim majority of 45.1 percent while 44.6 percent of the households in the region voted against the program.

Table 4. Results of Weighted (Representative) Preferences on the Referendum to Reduce Smoke for Washington Residents Only*

Response	Spokane Co.	Eastern WA	Washington Total
Favor Program	374 (50.1)	290 (38.9)	664 (44.5)
Against Program	302 (40.5)	375 (50.3)	677 (45.4)
Would Not Vote	14 (1.9)	8.8 (1.2)	25 (1.5)
Depends on Cost	2 (0.3)	0 (0.0)	2 (0.1)
Not sure/No Opinion	48 (6.4)	56.25 (7.6)	114 (7.0)
No Answer	6 (0.8)	15 (2.0)	22 (1.4)
Column Total	746	745	1491 (100.0)

* Numbers in parenthesis are column percents except Column Total which are row percents.

Table 5. Results of Revised Vote Count on the Referendum to Reduce Smoke For Entire Region[1]

Response	Spokane Co.[2]	Eastern WA[2]	No Idaho[2]	Region Total
Favor Program	357.7 (50.1)	274.8 (38.9)	71.15 (50.2)	703.6 (45.1
Against Program	288.8 (40.5)	355.4 (50.3)	51.7 (36.5)	695.9 (44.6
Would Not Vote	13.4 (1.9)	8.3 (1.2)	2.6 (1.8)	24.2 (1.6)
Depends on Cost	1.9 (0.3)	0 (0.0)	0 (0.0)	1.9 (0.1)
Not sure/No Opinion	45.9 (6.4)	53.3 (7.6)	13.6 (9.6)	112.8 (7.3)
No Answer	5.7 (0.8)	14.2 (2.0)	2.6 (1.8)	22.5 (1.4)
Column Total	713.4 (45.7)	706 (45.2)	141.7 (9.1)	1561 (100.0)

[1]Numbers in parenthesis are column percents except Column Total which are row percents.
[2]Weights for each region are 0.96 for Spokane County, 1.18 for Eastern Washington, and 0.65 for Northern Idaho.

To understand the motivations behind the responses to the referendum question, a statistical model was used to analyze possible factors in determining why respondents voted the way they did. We analyzed only data from the survey so there may be other factors beyond the scope of the survey which influence opinions on this issue. We used a logit statistical model to analyze the survey data. The logit model is used to predict yes-no responses and similar qualitative dependent variables (See statistics or econometrics text such as Greene). The logit model predicts the relative proportion of the population which will vote yes or no. The logit model also adjusts for the fact that one does not want to predict that fewer than zero or more than 100 percent of the votes are yes or no.

Table 6 presents the definitions of the variables from the survey that were used in the logit model. Eleven different variables were tested to determine if they were factors in explaining why respondents voted the way they did. These included responses to how respondents ranked health risk, the benefit to reducing health risks to other households, and the nuisance smoke is to their household; and also responses to concerns about the program including causing financial burdens to farmers, overstating the health benefits of reducing smoke, and giving more importance to dealing with other issues like crime and funding education.

The results of the logit analysis can be found in Table 7. The estimated coefficients from the logit model are not directly interpretable. However, the signs on the coefficients indicate whether responses to the variable is a factor in explaining why the respondent voted for the rule. A positive coefficient indicates that, on average, responses to the variable resulted in a greater probability of voting for the program. The chi-squared statistic indicates whether the effect is statistically valid.

The model shows that those respondents who favored the rule placed greater importance on:
- health risks to their own household (HEATHR),
- health risks of other households (ODEATH),
- the nuisance caused by smoke (NUISSM), and
- the degree grass smoke contributes to air pollution (FACT_6).

Respondents who did not favor the rule felt the rule
- singled farmers out (FARMCAUB),
- placed financial burdens on farmers (FARMERB),
- overstated the health benefits (HEALTHOB),
- lacked importance compared to other issues (OTHISSUB), and
- infringed on farmers right to farm (FARMITB).

Also, those with higher incomes tended to vote for the program while residents of Eastern Washington outside Spokane tended to vote against the rule. All the variables in the model are significant at the at the .01 level except EWASH which is not quite significant at the .05 level

Table 6. Definition of Variables Used in Statistical (Logit) Model

Label	Question
HOWVOTE (Dependent Variable)	Suppose you were asked to vote on this smoke reduction program reducing the acres farmers can burn by 2/3 of past levels by 1997. Would you vote for or against the program? (1=favor, 0=against + would not vote + depends on how much it costs + not sure or no opinion + no answer)
EWASH	Resident of Eastern Washington (1=Yes, 0=No)
HEALTHR	Given the health status of people in YOUR household, how much of a health risk does smoke from field burning pose for your household? (1=an extreme risk, 2=serious, 3=moderate, 4=slight, or 5=no risk)
ODEATH	Would reducing the health risks of smoke from grass field burning to other outside of your household be a (1) great, (2) moderate, (3) slight, or (4) no benefit.
NUISSM	Overall, how much of a nuisance is grass field smoke for you and your household? (1=great nuisance, 2=moderate, 3=slight, or 4=not a nuisance)
FARMERB	Regulations on grass burning may put additional financial burdens on farmers. (1=strongly agree, 2=somewhat agree, 3=somewhat disagree, or 4=strongly disagree)
HEALTHOB	Those who favor regulations on burning exaggerate the health problems caused by smoke. (1=strongly agree, 2=somewhat agree, 3=somewhat disagree, 4=strongly disagree)
FARMCAUB	Farmers are being unfairly singled out for causing air pollution. (1=strongly agree, 2=somewhat agree, 3=somewhat disagree, or 4=strongly disagree)
OTHISSUB	There are more important issues than air quality like controlling crime and funding education. (1=strongly agree, 2=somewhat agree, 3=somewhat disagree, or 4=strongly disagree)
FARMRITB	Farmers have a right to farm their land as they best see fit. (1=strongly agree, 2=somewhat agree, 3=somewhat disagree, or 4=strongly disagree)
FACT_6	To what extent do you think smoke from grass field burning contributes to air pollution. (1=major, 2=moderate, 3=minor, or 4=insignificant contributor)
INCOME 1995	Total household income before taxes for 1995. (1=less than $10,000, 2=$10,000-$20,000, 3=$20,000-$30,000, 4=$30,000-$40,000, 5=$40,000 to $60,000, 6=$60,000-$80,000, 7=over $80,0000)

Table 7. Results of Logit Model

Variable	Results*	
EWASH	- 0.31	(0.0522)
HEALTHR	0.30	(0.0056)
ODEATH	0.48	(0.0001)
NUISSM	0.46	(0.0001)
FARMERB	- 0.39	(0.0001)
HEALTHOB	- 0.31	(0.0001)
FARMCAUB	- 0.19	(0.0020)
OTHISSUB	- 0.13	(0.0483)
FARMRITB	- 0.26	(0.0001)
FACT_6	0.27	(0.0022)
INCOME 1995	0.11	(0.0296)

*Chi-squared probability values for the test of significance for individual variables are in parenthesis.

One limitation to the logit model is that the analysis could only be conducted on 1,467 observations. Ninety-four cases were not asked the questions about health risks or about concerns with the rule. In order to keep the duration of the interview down, farmer operators who were asked other questions about their farm operation. So the logit analysis is based mostly on the non-farm population.

Calculating Willingness-to-Pay Estimates from Contingent Valuation Survey

Respondents voting in favor of the rule or who indicated that (1) they would not vote, (2) their vote would depend on cost, (3) they were not sure or no opinion, or (4) they had no answer, were asked follow-up questions concerning how much their household would be willing to pay to get the benefits of the rule. (Those who did not favor the rule were asked if they would be willing to pay to continue to allow burning; see earlier discussion.) Those respondents that voted against the rule were asked follow-up questions to determine if they were either "true" zero values or if they were protesting against the idea of paying for the rule or against the referendum format.[4]

Information on willingness-to-pay (WTP) for the program was collected using two different types of question formats. A quarter of the sample was given the open-ended question format which just simply asks the respondent how much they would pay for the program. An alternative

[4] A protest vote or a protest zero value is one where the respondents objects to being asked to pay for a rule for several reasons including: (1) respondents feel polluters should pay for the rule, (2) respondents may object to the payment vehicle (in this case increase taxes) as inappropriate, or (3) respondents may want a reduction in smoke but dislike the approach taken to reduce it.

format called discrete choice was used for the remaining three-quarters of the sample. Here, respondents are asked if they would pay some set amount for the program. For this survey, the set amounts were $10, $20, $25, $30, $40, $50, $75, $100, $150, and $200.[5] These amounts were chosen based on the distribution of opened-ended responses from earlier interviews. The amounts were chosen to represent approximately equal proportions of the population. For each respondent, the set amount was randomly selected. If respondents agreed to pay the amount, a follow-up question asked the maximum amount the respondent would pay. If the respondent declined to pay the set amount, a follow-up question asked what amount, if any, the respondent would pay for the program. The responses to the follow-up questions in the discreet choice format were combined with the responses from the open-ended responses to form one continuous measure of WTP for the entire sample. This combined set of responses is used as the basis for WTP estimates in this report.

Table 8 shows the average WTP values for those who expressed a positive value, by each region. The table shows the number of positive responses, the percentage of positive responses within each region, and the standard error about the mean.

Table 8. Means for Positive WTP Value Responses

Region	% of Sample	Mean	Std Error
Spokane County (N=246)	33	$49.39	3.49
Eastern WA (N=138)	23	$54.12	4.43
Northern Idaho (N=70)	32	$81.35	18.15

Row one of Table 9 shows the aggregate WTP values for the proposed rule based on the mean WTP for all initial positive value responses. The mean values are then extrapolated to the total regional population based on the proportions of the sample that gave a positive WTP. However, this estimate represents a low estimate of the economic benefits of the proposed rule.

The reason the estimate in row one is low is that it assumes that all the respondents who did not exactly know their WTP had a zero value for the program. However, some respondents will have a positive value for the program but be unable or unwilling ("protest zeros") to express it. The other calculations in Table 9 account for households that could not provide explicit economic values using several different methods of imputing value for these "missing values." Imputing WTP values for these "don't know" households is an important calculation because follow-up responses indicate these households may have some value to the program. (See, e.g., Mitchell and Carson for an extensive discussion of this issue.) Explanations for these missing value observations include:

[5]These amounts were chosen based on the distribution of open-ended responses from the pretest interviews. Once chosen, each amount was randomly assigned to each interview in order to get an equal number of responses at each bid level.

Table 9. Aggregated WTP Benefits With Different Estimators

Type of Estimate	Mean Estimate ($ Millions)	Range[1] ($ Millions)
1. Low Estimate: Mean of Positive Responses Only (n=454)	5.4	4.3 to 6.4
2. Moderate Estimate: Positive and Missing Value Estimate using Mean of Positive and Zero Value Cases for Missing Value Estimate (n=770)	7.4	5.9 to 9.0
3. High Estimate: Positive and Missing Value Estimate using Mean of Positive Value Cases Only (n=770)	9.2	7.3 to 11.0
4. Best Estimate: Positive and Missing Value Estimate using OLS estimates for Missing Cases (N=770)	8.4	6.6 to 10.2

[1]Range based on 95 percent confidence interval based on two standard errors of the mean.

- respondents are protesting against paying because they feel polluters should pay for the damage,
- respondents would like to improve air quality but do not trust the government to properly implement the rule, or
- respondents are not able to provide any value information without being provided more information about the program
- respondents can't or won't express their value in monetary terms.

In all, there are 316 observations that can be considered either protests or not sure households.

Three alternative approaches to imputing value to missing households were used. One approach was to give these missing households the mean values based on all households with positive values. These calculations represent a high estimate and can be found at row 3 in Table 9. In the high case, we essentially assume that the "don't know" households are like those that offered positive values. In the conservative approach (row 1), we assume that "don't know" households are like those who have zero value. A more moderate approach would impute a value based on a combined mean calculated from all positive value households and those households with "true" zero values. Aggregations based on these means can be found at row 2 in Table 9.

Finally, the last approach uses values for missing households that have been statistically predicted. We used ordinary least squares (OLS) regression models to predict these "missing values." These models use key relationships from other variables in the survey to explain how much a household is willing-to-pay for a reduction in smoke. Based on these quantifiable relationships, predicted values for missing households can be estimated based on their responses to variables in the OLS model (the models used are presented in a separate technical appendix, along with the questionnaire, that can be obtained by request). The assumption is that the responses to other variables in the questionnaire by households that did not give a value is similar to the responses of households that did provide values.

The use of both the mean of positive values and mean from predicted values (for missing cases) are presented in row 4 of Table 9. This estimate represents our best estimate for the amount households are willing to pay for the smoke reduction program since the use of models to predict WTP is the best method for filling in "missing values." (See, for example, Mitchell and Carson.) The range around the estimate is based on the margin of error in extrapolating the benefit value from the sample population to the total population. Our use of a relatively large sample (1561 households) compared to many studies of this type helps to minimize this margin of error.

Compensation Measure of Benefits

An alternative measure of the economic benefits of a smoke reduction program can come from an additional compensation value question. The "compensation question" asked respondents how much their household should be compensated in the absence of a smoke reduction rule. In the compensation question households are asked how much they must be compensated to "sell" their right to the the effects of the proposed rule (cleaner air), rather than how much they would pay to get the rule implemented. It is based on the assumption that the population affected by smoke has the right to be free of smoke. If they have the right to be free of smoke they should not have to pay to get reduced smoke, they should be compensated for any damages caused by continued burning. This approach produces much larger estimates of the value of smoke reduction. The compensation question was asked of all respondents except primary farm operators and those who voted against the program and agreed to pay to allow continued burning.

Table 10 shows the distribution of the 104 respondents who said they should be compensated. Table 11 presents the mean compensation values and the aggregated value by region. Fifty-six respondents did give an amount they would require for compensation.

Overall, extrapolating the compensation value to the entire region gives a total value of approximately $328 million based on positive responses given to the compensation question. In addition to those who indicated how much compensation they needed to allow burning to continue, an additional 48 respondents wanted compensation for burning to continue but did not place a value on the compensation because they were not sure or needed more information before they could give an amount. If the mean of the compensation values from those who did give a value is used as a measure for these missing households, the overall level of compensation would be $543.3 million.

Table 10. Number of Households Wanting Compensation By Region[1]

Region	Household Wanting Compensation
Spokane County	56 (9.61)
Eastern Washington	26 (5.95)
Northern Idaho	22 (13.10)
Total	104 (8.75)

[1]All numbers in parenthesis show the percentage of those wanting compensation in each region. The parenthesis for the total row shows the percentage of those wanting compensation for the entire sample.

Table 11. Means for Compensation Value Responses*

Region	% of Sample with Postive	Mean	Total Value (millions)	Percent of Sample including Missing Value Household	Total Value Including Missing value Households (millions $)
Spokane County (Positive n=35; Missing n=21)	4.7 (7430)	$39,282	$291.87	7.5 (11,878)	466.6
Eastern WA (Positive n=12; Missing n=14)	2.0 (3155)	$11,212	$ 35.37	4.3 (6739)	75.6
Northern Idaho (Positive n=11; Missing n=11)	5.0 (1579)	$ 359	$ 0.57	10.0 (3145)	1.1
TOTAL			$327.81		543.3

* Numbers in Parenthesis are the number of households represented by the sample for each region.

Compensation measures are not often used in economic valuation studies partly due to the wide range of values respondents report. In this study, the range of values given for compensation was from $10 to $1.3 million. A better estimator of required compensation for continued burning at 100 percent is a "trimmed mean." (Mitchell and Carson) A trimmed mean is based on discarding the extreme lowest values and the extreme highest values and calculating the mean based on the remaining observations. Table 12 provides a calculation of an aggregate compensation value using a trimmed mean. Throwing out the three lowest observations ($10, $15, and $20) and the three highest values ($50,000; $100,000; and $1.3 million) produces means that are less influenced by extremely large values.

Table 12. "Trimmed" Mean Estimates of Compensation Value Responses*

Region	% of Sample	Mean	Total Value (millions)	% of Sample Including Missing Value Households	Total Value Including Missing Value Households (millions $)
Spokane County (Positive n=35; Missing n=21)	4.7 (7430)	$ 886	$ 6.4	7.5 (11,878)	10.5
Eastern WA (Positive n=12; Missing n=14)	2.0 (3155)	$ 3,836	$10.8	4.3 (6735)	25.8
Northern Idaho (Positive n=11; Missing n=11)	5.0 (1579)	$ 393	$ 0.6	10.0 (3145)	1.2
TOTAL			$ 17.8		37.5

* Numbers in Parenthesis are the number of households represented by the sample for each region.

Based on the trimmed mean as an estimator of compensation values, the aggregate compensation value is $17.8 million for those willing to express a monetary value. If this value is expanded to include missing value observations, the level of compensation increases to $31 million.

Conceptually, the question of whether it is the right of farmers to burn their fields or the right of local residents to clean air that should be paramount is a legal and moral question beyond the scope of this study. This right should determine whether willingness to pay or compensation is used to estimate benefits. However, the compensation estimate is unreliable. The compensation value is based on a very small number of respondents so that extending the estimate to the whole population requires a very large confidence interval--range of estimate of the error. Moreover, as noted in the discussion of trimmed means respondent reporting patterns are less stable for compensation questions because they are characterized by a great range of individual value estimates. Most economists and government agencies disallow compensation estimates for these practical reasons. For instance, the National Oceanic and Atmospheric Administration disallows compensation estimates based on the recommendations of a blue ribbon panel of economists.

Conclusions

Results from the survey indicated a range of potential values that can be realized from the proposed smoke reduction rule. Estimated benefits range from a low of $5.3 million (based on willingness-to-pay) to a possible $31 million in benefits (base on willingness-to-accept compensation using a trimmed mean). Our best estimate accounting for most of the potential willingness-to-pay is $8.4 million with a range of $6.6 to $10.2 million. The range is based on the confidence interval of the estimate--the potential error in extrapolating the estimate based on the sample to the entire population. We used a relatively large sample size to minimize this error.

The willingness to pay estimate using contingent valuation captures most of the total value of the proposed rule. However, there are several reasons that WTP estimate may not include all benefits. One reason is that many respondents did not like the fact that the proposed rule to reduce smoke would impose a burden on local farmers. They therefore discounted the value they were willing to pay for the program to account for this negative impact. This can be seen especially outside the Spokane and North Idaho areas. While the majority of households in Spokane and Northern Idaho favor the proposed rule, the majority of residents in other areas of Eastern Washington oppose the rule. These results imply that the willingness to pay for the smoke production is a net value: it is the value of the benefits of smoke reduction to households less a penalty or cost for the burdens of the program.

Another reason the WTP estimate is low is that it measures benefits only from a private perspective. This means that, in evaluating their costs, households consider <u>their</u> costs for, say, hospitalization, but not the cost paid by insurance or government programs. This means that the survey based WTP benefit estimate is likely to be understated because it does not include costs to general businesses and the public. Thus, losses to the recreation industry in Northern Idaho are not included, though the cost of lost recreation days to the individual are included. The health exposure based estimates which follow are also understated because they do not include non-health benefits at all.

Health Related Benefits of Reducing Particulate Pollution

To supplement the benefit estimates from the contingent valuation survey, this section presents estimates of the health benefits of reducing smoke from agricultural field burning based on secondary sources. This analysis is based on extensive data in the epidemiological literature on the impacts of airborne particles on human health. We have used a standard approach of first determining exposure estimates and assigning health impacts based on the epidemiological literature. Once health impacts are estimated, economic impacts are assessed based on results from general studies in the literature. See Freeman for an account of this approach.

A useful example of the epidemiological-economic approach to air pollution can be found in *Dollars and Cents: The Economic and Health Benefits of Potential Particulate Matter Reductions in the United States*, a report prepared by Lauraine G. Chestnut of Hagler Baily Consulting, Inc. for the American Lung Association. The Chestnut reference provides a synthesis of available epidemiology studies. It then combines these results with potential economic values for improving air quality to make estimates of the economic benefits of reducing particulate pollution to the PM_{10} standard established by the state of California. The Chestnut report includes daily health risk relationships between particulate pollution and number of indicators of public health. These relationships were adapted to provide estimates of the health benefits gained from the elimination of grass smoke.

Analysis of the health benefits from reducing the particulate pollution from grass smoke in Eastern Washington requires the following assumptions. In most cases we used assumptions that produce a conservative estimate of health benefits.

1. The analysis considers only how grass burning increases the background level of daily particulate pollution levels and not include direct plume effects. During the burning season (from August 1 to September 30), ambient PM_{10} levels can increase up to ten micrograms per cubic meter in Spokane County (source: Spokane County Air Pollution Control Authority), nine micrograms per cubic meter in Benton county (source: Benton County Clean Air Authority) and five micrograms per cubic meter in Kootenai County (source: Idaho Division of Environmental Quality). While PM_{10} levels in a plume of smoke can reach between 150 to 300 micrograms per cubic meter during burning and for one or two hours immediately afterward, there is not enough information to evaluate the health effect of these plumes. Generating such information would require a model to estimate exposures that was well beyond the time and resource constraints of this study. Therefore, we analyze here only the effect of the increase in background level particulate during the burn season. Therefore, this analysis will only provide a lower bound or base level estimate of the health benefits of reduce burning for Eastern Washington.

2. The Lung Association report provides a range of estimates (a low, central, and high) of the relative risks that the general population faces from particulate pollution exposure. Also, a range is provided for the economic values associated with each health effect. Eastern Washington is likely to differ in both the characteristics of its population and in its economic values from other parts of the country. Thus, it is reported that Spokane has twice the national level incidence of asthma which will mean that its population is more at risk than is typical. On the economic side, Spokane has a lower household income which usually produces lower economic values. We have used the central estimates of health related risks and the central value economic estimates for this analysis. This assumes that everyone in the

population faces the same health risks, which is clearly not the case, but the central is a good approximation for the purposes of this report without better data to adjust the figures.

3. Because the burn season lasts only 60 days, only the health effects for which daily incidence rates could be found were evaluated. These include: the effects of reducing premature mortality, respiratory hospital admissions, emergency room visits, restricted activity days, asthma symptom day, and acute respiratory symptoms day. Other effects have annual incidence rates which would have required some method for apportioning the annual figures to a shorter season. These include health effects such as bronchitis episodes.

Health Outcomes

To conduct this analysis, we assume that the measurements of particulate levels from Benton County as representative of particulate levels for the counties in Eastern Washington where bluegrass is grown. Likewise, we assume that the measurements of particulate levels in Kootenai County in Idaho is representative of levels in Bonner County . Table 13 presents a summary of the concentration response relationships (the expected health outcomes for a given population based on a dose or exposure to particulate) that are used to measure the health effects of particulate pollution in the region.

Table 13. Human Health Effects Associated with PM_{10}

Health Effect Category	Concentration-Response
Daily mortality risk factors given a 1 mg/m³ change in daily PM_{10} concentration. Various sources: Including Pope, et al. (1995), and Dockery, et al. (1993).	C 3.3×10^{-8}
Respiratory hospital admissions (RHAs) daily risk factors given a 1 mg/m³ change in PM_{10} concentration. Source: Pope (1991)	C 3.3×10^{-8}
Emergency room visits (ERVs) daily risk factors given a 1 mg/m³ change in daily PM_{10} concentration. Sources: Samet, et al. (1981)	C 6.5×10^{-7}
Asthma symptom days (ASDs) daily risk factors given a 1 mg/m³ change in daily PM_{10} concentration. Sources: Whittemore and Korn (1980), Ostro, et al. (1991)	For population with asthma (4.7% of population)[6] C 1.6×10^{-4}
Restricted activity days (RADs) daily risk factors given a 1 mg/m³ change in daily PM_{10} concentration. Sources: Ostro (1987), Ostro and Rothschild (1989)	For population aged 18 years and over: C 1.6×10^{-4}
Days with acute respiratory symptoms (ARSs) daily risk factors given a 1 mg/m³ change in daily PM_{10} concentration. Source: Krupnick, et al. (1990)	C 4.6×10^{-4}

[6] Spokane has a rate of asthma (10 percent) which is higher than the national average. For these calculations, the higher rate was use for Spokane County while 4.7 percent was used everywhere else.

Calculating the effect on daily mortality of a 10 microgram per cubic meter increase in particulate matter in Spokane County will illustrate how these relationships are used. The general form of the formula is given as:[7]

(1) $3.3 * 10^{-8} * (\Delta PM_j) * (\text{Population})$

Taking the relative risk of daily mortality and multiplying it by both the daily change in particulate ($\Delta PM_j = 10$ micrograms per cubic meter) and the 1995 population estimate of Spokane County yield the following expression:

(2) $3.3 * 10^{-8} * 10 * 401{,}200 = 0.132$

which is the expected increase in daily mortality for Spokane County from a 10 microgram per cubic meter increase in PM_{10}. Multiplying by 0.1.32 by 60 days gives an increase of 8 deaths that are due to the increase in PM_{10} over the entire burning season. The remaining health outcomes are calculated in the same way.

Valuation of Health Effects

Once the health outcome is identified, the outcome is multiplied by the associated dollar value found in Table 14 to provide an estimate of the economic benefit to be gained if particulate from grass smoke is eliminated. The dollar values from the various economic studies are adjusted to first quarter 1995 dollars.

Of special note is the value of a statistical life estimate that is used to value premature mortality. While the value of an individual life (or death) is immeasurable, value can and is placed on changes in risk of death. To illustrate, people drive cars, enter certain occupations, and engage in other activities that have differing risks associated with them. Based on the different value that people place on risks, a value for a statistical life can be calculated. It is not a value for a life per se, but a value placed on the increase in likelihood that one additional person will die. The figure selected for this analysis is $4.5 million per statistical life as recommended in the *Ecology Economics Resource Book* (Carruthers). However, this figure has been adjusted downward given that approximately 85 percent of premature deaths from particulate pollution are 65 or older (Chestnut, 1995, p. 5-9). Since the willingness-to-pay for mortality risks is less for those over 65, Chestnut recommends adjusting the "value of a statistical life" estimates downward by 30 percent.

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[7] Note that the incidence rate is applied to the whole population, not just the at-risk population for Spokane. The incidence rates are already adjusted for the proportion of the general population which is at risk for the particular health effect.

Table 14. Summary of Selected Monetary Values for Various Health Effects

Health Effect	Estimate per Incident (1Q95$)	Primary Source	Type of Estimate[1]
Premature mortality (VSL)	3.15 mil.	Viscusi, et al. 1992	WTP
Respiratory hospital admission	15,000	Krupnick and Cropper (1989)	Adjusted COI
Emergency room visit	500	Rowe, et al. (1986)	Adjusted COI
Restricted activity day	60	Loehman, et al. (1979)	WTP & Adjusted COI
Asthma symptom day	36	Rowe and Chestnut (1986)	WTP
Acute respiratory symptom day	12	Loehman, et al. (1979) Tolley, et al. (1986)	WTP

[1] WTP = Contingent valuation WTP estimate.
Adjusted COI = COI x 2 to approximate WTP.

The estimates for respiratory hospital admissions, and emergency room visits are from studies that actually measure the cost of illness (COI) associated with each service. Chestnut (1995, p. B-8) recommends multiplying COI estimates by 2 in order to get a better estimate of WTP for benefit-cost analysis.

Table 15 presents the total damage estimate from all particulate pollution above background levels during the length of the burn season for the entire region. It is estimated that the increase in background levels of PM_{10} during August and September each year results in $54 million in health effects. The most significant health effect is the $50 million in economic loss due to 16 premature deaths that can occur during the burn season.

Since the value in the Table 15 shows damage from airborne particulates from all sources, the figures must be adjusted to determine the benefit of reducing the particulate due to burning bluegrass seed fields. If smoke from the burning of bluegrass fields accounts for between one-quarter and one-half of the particulate level increases during the burn season, then the total economic loss due to grass smoke ranges from 13.6 to 27.2 million dollars. Since the proposed rule would reduce smoke from bluegrass field burning by two-thirds, the benefits of the rule would range from 9.1 to 18.2 million dollars (two-thirds of 13.6 and 27.2).

Table 15. Economic Costs of Increasing Particulate Levels During Burn Season

Health Effect	Spokane Co. (10 mg/m^3)	Eastern WA (9 mg/m^3)	NO Idaho (5 mg/m^3)	Dollar Value	Total $
Premature Death	8	7	1	3,150,000	50,400,000
Respiratory Hospital Admissions	8	7	1	15,000	240,000
Emergency Room Visits	156	134	24	500	157,000
Asthma Symptom Days	3,851	1,554	278	36	204,588
Restricted Activity Days	26,960	23,148	4,141	60	3,254,940
Acute Respiratory Symptoms	110,731	95,075	17,010	12	222,816
TOTAL					$ 54,479,344

INCIDENCE OF ILLNESS DUE TO SMOKE: SURVEY RESULTS

To better understand the public health impact of exposure to smoke from field burning, the contingent valuation questionnaire also gathered information on area residents who have chronic respiratory or heart conditions. Because of the difficulty respondents may have in identifying the source of smoke (wheat stubble versus grass fields), the questions were designed to measure behavior in responses to smoke from any field burning. Therefore, not all behaviors are the result of being exposed to smoke from the burning of bluegrass fields, but should be interpreted in the broader context of all field burning. This analysis is consistent with the previous section where exposures to the regions population were based on increased particulate pollution levels observed during the summer months of August and September.

The survey contained a series of questions on the last time any member of the household with a chronic respiratory or heart condition sought additional medical care outside of their regularly scheduled checkups. If so, the respondents were asked about their condition, what additional medical services they used, what symptoms they experienced, and if their symptoms could be caused by smoke. Of the 1,561 interviews completed, 253 households (16.2 percent of the sample) have a member with a chronic respiratory or heart condition. Table 16 shows the distribution of the number of households that have a member with a chronic condition by region.

Table 16. Number and Percentage of Households with Chronic Condition

Region	Number of Households	Percentage of Sample
Spokane County	123	16.5
Eastern Washington	90	15.1
Northern Idaho	40	18.3
Overall Sample	253	16.2

Based on information from this section of the survey, a profile of the potential health impacts was constructed for those individuals whose symptoms may be caused by smoke from outdoor field burning. Of the 253 households that contained someone with a chronic respiratory or heart condition, 69 of these (4.4 percent of the total sample) stated that their symptoms can be caused by exposure to smoke from field burning (47 of this identified the source of smoke as coming from the burning of bluegrass fields). Table 17 contains a listing of the chronic respiratory conditions for these households. The most frequently reported condition is asthma (50 total), with 39 households having asthma only and an additional eleven households having asthma with some other condition.

These households were asked about the last time additional medical care, outside of their normal checkups, was needed by someone in their household. Of these 69 respondents, 95 percent have experienced at least one episode where additional medical care was needed to treat their symptoms between 1992 and 1996. Table 18 summarizes the services used. The variety of services range from doctor visits to admission to the hospital. A majority of the households used more than one service. Forty chronic cases had to visit a doctor, while 19 visited an emergency room (ER) or a minor ER clinic, and 10 were admitted to a hospital.

Using the economic information from Table 10, the economic loss of the ten hospital admissions is $150,000 while the economic loss of 19 emergency room visits are $9,000.

Valuation of Symptoms Requiring Additional Medical Treatment

Table 19 contains a summary of the various symptoms experienced by household members with a chronic respiratory or heart disease. Using secondary information, an economic value can be place on reducing just one incidence of each symptom. Economic values used are in 1991 dollars. These values range from $17 to avoid an episode where breathing is difficult to $65 to avoid one headache.

Table 17. Chronic Respiratory Conditions for Those Households Reporting Symptoms Caused by Smoke

Condition	Number of Households
Asthma	39
Asthma and Sinusitis	1
Asthma and Chronic Bronchitis	2
Asthma, Chronic Bronchitis, Sinusitis	2
Asthma and Emphysema	4
Asthma, Emphysema, Chronic Bronchitis	1
Asthma, Emphysema, Sinusitis	1
Emphysema and Chronic Bronchitis	1
Emphysema, Chronic Bronchitis, Sinusitis	1
Emphysema	1
Chronic Bronchitis	4
Sinusitis	2
Lung Cancer and Angina	1
Other Lung or Heart Problems	9
TOTAL	69

Table 18. Additional Medical Services Used Treating Symptoms

Services Used	Frequency
Emergency Room/Minor ER Visit	19
Visit Doctor	40
Check into Hospital	10
Home Visit by Doctor	4
Visit by Nurse Practitioner	5
Additional Medication	28
Purchase Additional Oxygen	8
Visit a Lung Specialist	1

Table 19. Valuation of Symptoms Experienced the Last Time Additional Medical Case Was Needed by Households Reporting Symptoms Caused by Smoke

Symptoms	Frequency of Symptom	Unit Value (1991 $)	Total Value
Chest Pains	9	$ 22[1]	$ 198
Bronchial Spasm	10	$ 30[1]	$ 300
Asthma Episode	32	$ 45[2]	$1440
Difficulty Breathing	46	$ 17[1]	$ 782
Coughing Spell	22	$ 25[2]	$ 550
Sinuses	13	$ 45[2]	$ 585
Throat Congestion	6	$ 35[2]	$ 210
Itching Eyes	2	$ 35[2]	$ 70
Headache	3	$ 65[2]	$ 195
High Blood Pressure	1	N/A	N/A
Total Dollar Value			$4330

[1]Source: Dickie et. al. (1987)--Values adjusted to 1991 dollars.
[2]Source: Tolley et. al. (1994)

Based on the symptoms experienced the last time additional medical treatment was needed, the total economic value of avoiding one incidence of these symptoms is $4,330.[8] This value is an upper bound for total value for it should be weighted by the frequency of exposure to smoke from field burning in any year. However, if each household does experience these symptoms just once a burn season, then this value would reflect the economic loss due to one exposure to smoke from field burning.

Table 20 presents the aggregated regional economic damage of suffering one incidence of these symptoms. With 346,534 households represented by the sample, the number of households with chronic conditions (4.4 percent) is 15,247. Multiplying these chronic households by $4,330

[8]$4,330 is the value for the 69 households producing an average of $62.75 per household per incident (June 1997).

Table 20. Value of Symptoms When Additional Treatment was Needed

Total Households	Households with Chronic Conditions	$ Value of Symptoms	Total Economic Value
346,534	15,247	$4,330	$66 million
Revised, June 1997	per household	$63	$960 thousand

yields a total value of $66 million.[9] Caution must be exercised when interpreting this number for it represents the economic loss to individuals suffering symptoms that can be caused by one incidence of exposure to smoke, mostly occurring between 1992 and 1996. This number represents an aggregate of the economic damage accrued over this time period.

The survey did not collect information on the frequency of exposure to smoke that required additional medical care. However, the value above is still substantial. It should be noted that 61 percent of the households (n=42) suffering symptoms due to smoke from field burning identified the source of smoke they are exposed to as coming from bluegrass field burning.

Expenditures to Mitigate Minor Symptoms

Additional economic information on expenditures to mitigate minor symptoms were also collected in the contingent valuation survey. Respondents were asked if smoke from field burning ever caused someone in their household to suffer symptoms such as stuffy nose, watery eyes, coughing, headache, and mild bronchitis. A total of 613 respondents (39.27 percent of sample) said that they do suffer minor symptoms from smoke from field burning. These respondents (along with 43 respondents who answered that they were not sure) were further asked how likely would it be that someone in their household would purchase any medication to treat these minor symptoms. Overall, 224 respondents said they were very likely, 115 said somewhat likely, and 65 said somewhat unlikely that they would buy medication to treat these symptoms. This group was further asked how much money they would spend each time they suffered these symptoms due to smoke from field burning. Table 21 shows the average amount spent per household within each region and the aggregated total amount spent by region.

Overall, residents in the region are estimated to spend $2.6 million to treat minor symptoms each time they are exposed to smoke from field burning.

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[9]Revised calculation (June 1997 edition). The original value per incident calculation omitted a term. The correct calculation of (346,534 households) * (0.44) * $4330/69 yields a value of $957,000 per "incident." A value for the burning season would depend on how many "incidents" there were.

Table 21. Expenditures For Mitigating Minor Symptoms by Region

Region	% of Sample	Mean	Total Value (millions $)
Spokane County (n=160)	21	$38.5	$1.308
Eastern WA (n=88)	15	$46.1	$1.081
Northern Idaho (n=47)	21	$35.5	$0.234

CONCLUSIONS

The various analysis of potential benefits to reducing grass smoke yield a range of potential values. From the contingent valuation survey, the best estimate of willingness-to-pay to get the benefits of the proposed rule is $8.4 million with a range of $6.6 to $10.2 million. The best estimate of the value of compensation (also from the contingent valuation survey) is $31 million if values are imputed to missing observations.

Results for analysis using dose-response relationships and economic values from other studies indicate a potential economic loss of $54 million due to rising particulate levels in the region during the burn season. If grass smoke accounts for between one-quarter and one-half of the particulate levels, the economic benefits of the proposed rule range from approximately $9 to $18 million.

Analysis of the incidence of symptoms indicates that as much as $60 million in economic damage occurred from 1992 to 1996 to individuals that had to seek additional medical care due to exposure to smoke.[10] Although this estimate is a broader measure of the economic loss due to all smoke from field burning, it represents the potential economic impact on those households in the region that are at risk to exposure to smoke from field burning. Additionally, it is estimated that households in the region can spend up to $2.6 million to mitigate the minor symptoms each time they are exposed to smoke from field burning.

[10]Correction, June 1997. The correct cost of symptoms estimate is about $1 million per "incident." The number of "incidents" per season is unknown.

References[1]

Carruthers, Cathy. 1996. *Ecology Economics Resource Book: For Rule Writers who Must Comply with Economics Requirements in Washington Law. Draft.* Prepared for the Washington State Department of Ecology.

Chestnut, Lauraine. 1995. *Dollars and Cents: The Economic and Health Benefits of Potential Particulate Matter Reductions in the United States.* Report prepared for the American Lung Association, New York, New York.

Dickie, M.; Gerking, S.; McClelland, G.; and Schulze, W. 1987. *Improving Accruracy and Reducing Costs of Enviornmental Benefit Assessments.* Report to the Environmental Protection Agency. Washington D.C.: Environmental Protection Agency, December.

Dockery, D.W., C.A. Pope III, X. Xu, J.D. Spengler, J.H. Ware, M.E. Fay, B.G. Ferris, Jr., and F.E. Speizer. 1993. "An Association Between Air Pollution and Mortality in Six U.S. Cities." *The New England Journal of Medicine* 329(24):1753-9.

Forecasting Division, Office of Financial Management. 1995. *1995 Population Trends for Washington State: October 1995.* (Olympia, Washington: Forecasting Division of the Office of Financial Management).

*Freeman, A.M., III. 1993. *The Measurement of Environmental and Resource Values.* Washington DC: Resources for the Future.

Greene, W.H. *1990. Econometric Analysis.* New York: Macmillan Publishing Co.

Krupnick, A.J. and M.L Cropper. 1989. *Valuing Chronic Morbidity Damages: Medical Costs, Labor Market Effects, and Individual Valuations.* Final Report to U.S. Environmental Protection Agency, Office of Policy Analysis.

Krupnick, A.J., W. Harrington, and B.G. Ostro. 1990. "Ambient Ozone and Acute Health Effects: Evidence from Daily Data." *Journal of Environmental Economics and Management* 18(1):1-18.

Loehman, E.T., S.V. Berg, A.A. Arroyo, R.A. Hedinger, J.M. Swartz, M.E. Shaw, R.W. Fahien, V.H. De, R.P. Fisher, D.E. Rio, W.F. Rossley, and A.E.S. Green. 1979. "Distributional Analysis of Regional Benefits and Cost of Air Quality Control." *Journal of Environmental Economics and Management* 6:22-243.

[1]Citations omitted in earlier editions shown with *.

*Mitchell, R.C. and R.T. Carson. 1989. *Using Surveys to Value Public Goods*. Washington DC: Resources for the Future.

*Moore, C.V. and D. Villarejo. 1996. "Pesticide Cancellation and Kentucky Windage." *Choices* (3rd quarter):36-38.

Ostro, B.D., M.J. Lipsett, M.B. Wiener, and J.C.Selner. 1991. "Asthmatic Responses to Airborne Acid Aerosols." *American Journal of Public Health* 81:694-702.

Ostro, B.D. 1987. "Air Pollution and Morbidity Revisited: A Specification Test." *Journal of Environmental Economics and Management* 14:87-98.

Ostro, B.D. and S. Rothschild. 1989. "Air Pollution and Acute Respiratory Morbidity: An Observational Study of Multiple Pollutants." *Environmental Research* 50:238-247.

Pope, C.A. III, M.J. Thun, M.M. Namboodiri, D.W. Dockery, J.S. Evans, F.E. Speizer, and C.W. Heath, Jr. 1995. "Particulate Air Pollution as a Predictor of Mortality in a Prospective Study of U.S. Adults." *American Journal of Respiratory and Critical Care Medicine* 151:669-674.

Rowe, R.D. and L.G. Chestnut. 1986. *Oxidants and Asthmatics in Los Angeles in Los Angeles: A Benefits Analysis--Executive Summary*. Prepared by Energy and Resource Consultants, Inc. Report to the U.S. Environmental Protection Agency, Office of Policy Analysis. EPA-230-09086-018. Washington D.C.

Rowe, R.D., L.G. Chestnut, D.C. Petersen, and C. Miller. 1986. *The Benefits of Air Pollution Control in California*. Prepared for California Air Resources Board by Energy and Resources Consultants, Inc., Boulder, Colorado. Contract No. A2-118-32.

Samet, J.M., F.E. Spieaer, Y. Bishop, J.D. Spengler, and B.G. Ferris, Jr. 1981. "The Relationship Between Air Pollution and Emergency Room Visits in an Industrial Community." *Journal of the Air Pollution Control Association* 31(3):236-240.

Tolley, G.S., L. Babcock, M. Berger, A. Bilotti, G. Blomquist, R. Fabian, G. Fishelson, C. Kahn, A. Kelly, D. Kendel. R. Kumm, T. Miller, R. Ohsfeldt, S. Rosen, W. Webb, W. Wilson, and M. Zelder. 1986. *Valuation of Reductions in Human Health Symptoms and Risks*. Prepared at the University of Chicago. Final Report for the U.S. Environmental Protection Agency, CR-811053-01-0.

Tolley, G.; Kenkel, D.; and Fabian, R. 1994. "State of the Art Health Values." in *Valuing Health for Policy: An Economic Approach*. George Tolley, et. al. eds. University of Chicago Press: 323-344.

Whittemore, A. and E. Korn. 1980. "Asthma and Air Pollution in the Los Angeles Area." *American Journal of Public Health* 70(7):687-696.